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The mystery origin
of Earth's dry land

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What we burn
fuels what we think

MYTHOLOGY VS SCIENCE
Telescopic battle over
Hawaii's sacred mountain

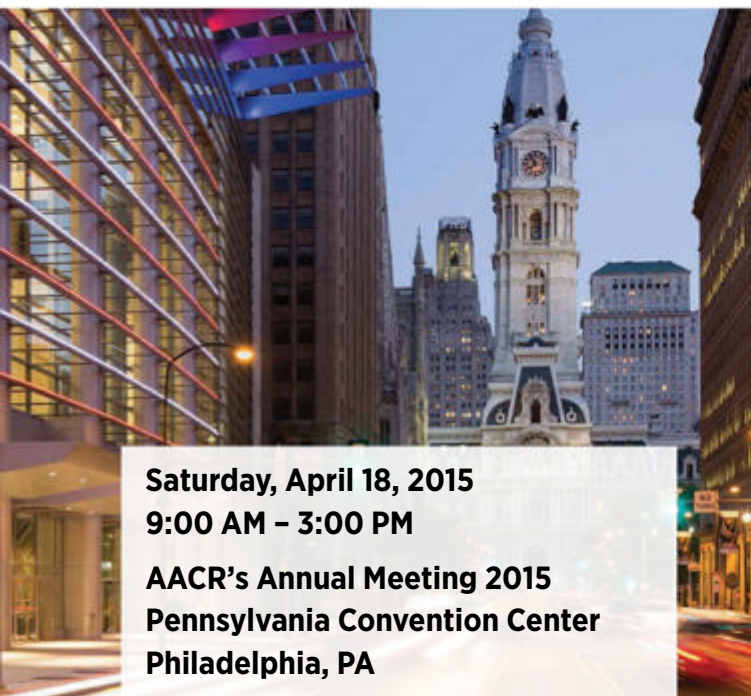
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Regaining sensation

Exoskeleton helps paralysed people feel again



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Lasting pick me up



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Bridging the divide

Politicians need to heed science's insights on inequality

WITH the UK general election campaign in full swing and candidates for the US presidency starting to declare themselves, it's becoming clear that one issue is central to debate on both sides of the Atlantic: inequality.

Not many politicians are talking about it directly. But the gulf between the haves and have-nots shows up in wrangling over everything from tax avoidance to benefit cuts, property ownership, corporate power and the erosion of the middle class.

The arguments tend to focus on economics and politics. But that overlooks the contribution that science can make. As we reported nearly three years ago, science has much to say about inequality's

causes and effects, from patterns of income distribution to the health consequences of living in unequal societies (28 July 2012, p 37). But these insights have not made their way into mainstream political debate.

Now comes a further twist: a society's level of inequality appears to be driven by the kinds of energy at its disposal. Foraging societies tend to be very equal and agrarian ones very unequal; those powered by fossil fuels fall in between (see page 28).

This new way of looking at the problem is very broad-brush, and its implications are not yet clear. It could be used to defend the status quo: inequality in today's Western societies is actually quite low by

historical standards. On the other hand, it is rising – and those historical standards are not necessarily desirable.

But the new analysis could be the start of a deeper debate that connects two of the key issues of our times. Just as with inequality, concern about our energy use is evident all over the political map, on issues ranging from defence to the environment.

The deep connection between the two has so far had little attention from academics, let alone politicians. Now that the fossil fuel economy is reaching the end of the road this needs to change. On both issues, science is speaking; politicians would do well to listen. ■

Seeing further

BACK in 1996, a spectator at a boat race on the Columbia river in the US stumbled upon an ancient human skull. Archaeologists soon found that the rest of the skeleton was intriguingly unlike that of other early Americans. But their work was contested by Native Americans, who saw "Kennewick Man" as an ancestor deserving respect – and reburial.

The resulting tussle over the

remains is still dragging on. It is not the only instance of scientists' aims conflicting with indigenous peoples' wishes: some geneticists made unauthorised use of blood samples – donated for diabetes research – to study Native American ancestry, for example.

Now it is astronomy's turn. The dispute over the siting of a new telescope on Mauna Kea in Hawaii is fuelled by the same concerns

about power, ownership and cultural imperialism (see page 11).

In such cases, it is tempting to see science as a hostage to irrationality. But scientists must respect these very human feelings, out of self-interest if nothing else.

Many Native Americans now refuse to take part in ancestry studies. If the telescope is not built, it will be a loss to science. But if it is built by alienating a community, the loss could be even greater. ■

Climate change on trial

IF GOVERNMENTS won't do it on their own, can courts force their hand? That's the hope of a Dutch environmental group called Urgenda, which this week presented a class action suit over climate change.

Urgenda is suing the Dutch government on behalf of some 900 citizens, including children. The suit claims that the government's action to reduce greenhouse gas emissions is insufficient, and is therefore "knowingly exposing its own citizens to dangerous situations".

The group is asking that the courts "declare that global warming of more than 2°C will lead to a violation of fundamental human rights worldwide". According to the Intergovernmental Panel on Climate Change, governments must cut

emissions to between 25 and 40 per cent below 1990 levels by 2020 to have a 50 per cent chance of avoiding 2°C. Yet European Union states have signed up for 40 per cent cuts by 2030.

"It would be groundbreaking for Urgenda to win," says James Arrandale of the London-based environmental law firm Client Earth. He says it would lead to similar suits in other countries. A Belgian group is already on the case.

A key point, says Arrandale, is to show that governments already have legal obligations to cut emissions, regardless of the outcome of the UN climate talks. To that end, a group of international legal experts published the Oslo Principles on 30 March, which set out existing legal obligations on governments to safeguard the climate.



SIEBE SWART/HOLLANDE-HOOFT/REX/NEVE

A dangerous situation?

Save world. Vote

CAN saving the world from climate chaos go hand in hand with saving the UK economy? Yes, if you believe the politicians.

This week, the parties began unveiling their manifestos ahead of the general election on 7 May. The Labour Party vowed "to make Britain a world leader in low carbon technologies". By boosting investment and research in renewable tech, it hopes to create a million new green jobs by 2025 and decarbonise electricity production by 2030.

"If you're serious about low-carbon technology, you must invest serious amounts"

The Conservative Party already claims to be "the greenest government ever", having trebled renewable energy production to 19 per cent of the total generated in the UK. New pledges in its manifesto include an extra £1 billion for schemes to capture and store carbon dioxide and a promise to push for a deal at the

UN climate talks in Paris in December that restricts future global warming to 2 degrees.

The Scottish National Party, Plaid Cymru and the Green Party are also pledging to invest in renewable energy.

However, it will take something of a sea change in attitude if green-tech promises are going to bring lasting economic prosperity as well as cleaner air, says Kieron Flanagan of Manchester Business School. Research and development in home-grown technology has been missing in the UK since the 1970s, he says, when governments stopped spending money on large-scale development in areas such as defence, computing and aerospace. Other countries have ploughed ahead via organisations such as the Defense Advanced Research Projects Agency in the US, and the 90 or so Fraunhofer technical institutes in Germany.

Parties have yet to spell out how much they're willing to spend. But, says Flanagan, "if you're serious about low-carbon technology, you must invest serious amounts".

Doctor Watson

THE supercomputer will see you now. IBM has announced it will partner with Apple and medical device companies Johnson & Johnson and Medtronic to develop a health platform for Watson, its supercomputer designed to learn the way a human does.

IBM Watson Health will develop a cloud-based database of constantly updated, anonymised health information collected from many sources, including health apps used by Apple

customers and fitness devices.

The database "will enable doctors and researchers to draw on real-time insights from consumer health and behavioural data at a scale never before possible", John E. Kelly, a senior vice president at IBM, said in a statement.

It may also enable people to take greater control of their own care. Medtronic, for example, wants to use Watson software to design personalised care plans for people with diabetes using the company's glucose monitors.

Comet's magnetic mystery

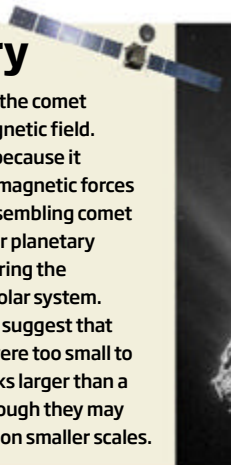
#ROSETTAWATCH

PLANETS weren't built by magnets. That's the latest from Philae, the European Space Agency lander that touched down on comet 67P/Churyumov-Gerasimenko last year.

The spacecraft's magnetic sensors show that Philae and its mother ship Rosetta, which is currently in orbit around 67P, detected similar readings throughout Philae's descent (*Science*, DOI: 10.1126/science.aaa5102).

In other words, the comet has almost no magnetic field. That's a surprise, because it was thought that magnetic forces played a role in assembling comet material into larger planetary building blocks during the formation of the solar system.

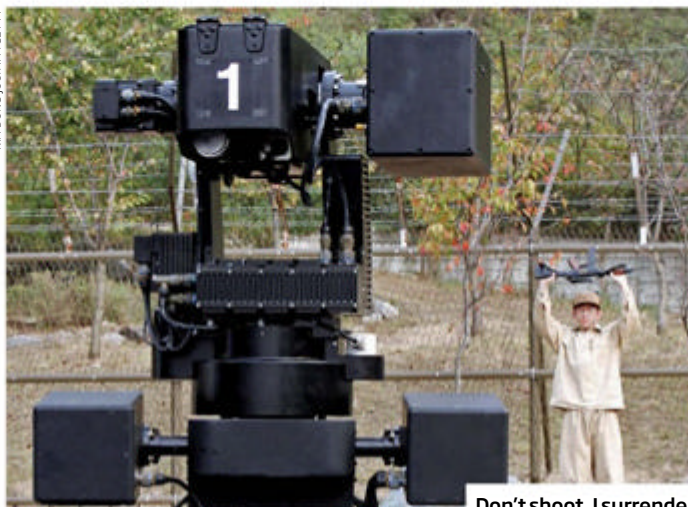
These readings suggest that magnetic forces were too small to fuse building blocks larger than a metre in size, although they may have played a role on smaller scales.



UK oil bonanza?

WELL, well, well. South-East England could be sitting on a huge oil field, as much as 100 billion barrels, according to media reports of last week's announcement by the UK Oil & Gas Investments.

KIM DONG-JO/AP/GETTY



Don't shoot, I surrender

"I'd be happier with their claims if they had a core and test-well data, but they should press on"

But some experts have since cautioned about over-hyping the find. Even UKOG chief executive Stephen Sanderson said further testing will be needed to prove the commercial viability.

Alastair Fraser of Imperial College London has questioned the reliability of the estimates, which rely on analysing the oil content of chips of Kimmeridge clay from 760 to 900 metres underground. A better approach, he says, would be to analyse a full cylindrical bore. "Then you know the depth of the oil-bearing deposits, where it comes from and that there's no contamination from higher up."

Fraser would also recommend a test well to see how much, if any, oil actually came out. "You could look at the oil, how fast it comes out and, most important, how fast it became depleted," says Fraser. "I'd be happier with their claims if they had a core and test-well data, but they should press on and see what they can get out."

Rein in the bots

CAN we control the killer robots? This week, the United Nations is hearing from technical and legal experts on the subject.

The series of briefings and panel debates at the UN Convention on Certain Conventional Weapons is the latest step to a potential treaty on lethal autonomous weapons.

Key to the discussions is what constitutes "meaningful human control" – what type of human

extreme form you can't just have weapons out there without any kind of human supervision," says Asaro. "But there is still disagreement and work to be done on how we define this as a legal term."

Even the most hopeful estimates suggest that a treaty or formal ban is at least a year or two away.

Vulcan launch

WANTED: helicopter pilot who can catch a falling rocket engine.

On Monday, United Launch Alliance (ULA), a joint venture between Boeing and Lockheed Martin, announced a new rocket, named Vulcan after the *Star Trek* aliens in a public vote.

ULA plans for Vulcan to eject its engines after launch, then have them deploy parachutes and be caught in mid-air by a nearby helicopter. Being able to reuse the engines would lower the cost of space flight.

The firm is aiming for its first launch in 2019, at a cost of \$100 million per flight. ULA currently launches NASA and other spacecraft on its Atlas and Delta rockets.

SpaceX, one of ULA's main competitors, is also developing reusable rockets and was set for a test flight as *New Scientist* went to press.

"You can't just have autonomous weapons out there without any kind of human supervision"

involvement is necessary in the process of killing someone on the battlefield?

Peter Asaro, a member of the International Committee on Robot Arms Control, is attending the talks. He says most people now feel it is unacceptable for robots to kill people without human intervention.

Asaro believes that several countries, such as South Korea, whose statements were somewhat cautious in previous delegations, have become more outspoken in their opposition to autonomous weaponry.

"I think there is consensus around the fact that in its most

60 SECONDS

Earth's hot core...

Our planet may have collided with a body rich in sulphur, such as Mercury, during its formation. A collision of this sort would have allowed conditions to be right for uranium and thorium to still be powering Earth's magnetic field today (*Nature*, DOI: 10.1038/nature14350).

...and its freezing past

What was the climate like when our planet was completely enveloped in ice? New estimates based on reconstructing oxygen isotope ratios show that even regions close to the equator were as cold as central Antarctica today – around -40 °C (*PNAS*, doi.org/3ng).

Robot chef

Dinner is robo-served. A robot chef can rustle up a crab bisque, seemingly on its own. The system, created by London-based Moley Robotics, tracked a former *MasterChef*-winner's hands in 3D as he prepared a dish. Two robotic hands then recreated every move in a specially designed kitchen. The firm hopes to have a commercial version ready in two years.

No plaice to go

Say goodbye to your haddock and chips. As the North Sea warms by some 1.8 °C over the next 50 years, haddock, plaice and lemon sole may struggle to survive as the deeper, cooler water they retreat to becomes too warm. Instead, fish such as sardines and anchovies that prefer warmer waters are likely to flourish (*Nature Climate Change*, doi.org/3nf).

Pills blunt emotions

Popping a paracetamol tablet may numb the pain, but it also appears to dull emotions. Students who took the drug, also called acetaminophen, reported less strong responses to emotional images, such as those of crying, malnourished children, or kids playing with kittens (*Psychological Science*, doi.org/3nh).



Not so attractive after all

ESA/ROSETTA/NAVCAM - CC BY-SA 4.0

Paralysed limbs reawoken

A thought-controlled exoskeleton is helping people use their legs again

Jessica Hamzelou

"I FELT the ball!" yelled Juliano Pinto as he kicked off the Football World Cup in Brazil last year. Pinto, aged 29 at the time, lost the use of his lower body after a car accident in 2006. "It was the most moving moment," says Miguel Nicolelis at Duke University in North Carolina, head of the Walk Again Project, which developed the thought-controlled exoskeleton that enabled Pinto to make his kick.

Since November 2013, Nicolelis and his team have been training Pinto and seven other people with similar injuries to use the exoskeleton – a robotic device that encases the limbs and converts brain signals into movement.

The device also feeds sensory information to its wearer, which seems to have partially reawakened their nervous system. When Nicolelis reassessed his volunteers after a year of training, he found that all eight people had regained sensations and the ability to move muscles in their once-paralysed limbs.

"Nobody expected it at all," says Nicolelis, who presented the results at the Brain Forum in Lausanne, Switzerland, on 31 March. "When we first saw the level of recovery, there was not a single person in the room with a dry eye."

When a person's spinal cord is injured, the connection between body and brain can be damaged, leaving them unable to feel or move parts of their body. If a few spinal nerves remain, people can sometimes regain control over their limbs, although this can involve years of rehabilitation.

But the odds of recovery are slashed for people diagnosed with a complete spinal cord

injury, in which the nerves are thought to be severed. This results in no feeling below the site of the injury. People can spend a lifetime feeling disconnected from their lower body, and tend to receive less physical therapy as a result. Just over a third of the 12,500 people who experience a spinal cord injury every year in the US have complete injuries.

The Walk Again Project's results suggest that rehabilitation with an exoskeleton might offer a

better future. Developed by a team of 156 people spanning the globe, the device reads the wearer's brain activity using an electrode cap. Activity patterns associated with the wearer's intention to move are translated into an electrical signal that moves the legs of the exoskeleton, allowing the person to walk.

The exoskeleton has another important feature: it provides tactile feedback to the wearer. A flexible bed of temperature, pressure and proximity sensors – what the team calls an artificial skin – lines the sole of each foot. When the wearer takes a step, a signal is relayed to their forearm,

which is still able to feel sensations. "You are driving the exoskeleton by thinking about what you want to do, and you are getting instantaneous feedback from the surface on how you're walking and how you're moving in space," says Nicolelis.

Seven of Nicolelis's eight volunteers have complete spinal cord injuries. At the start of the training, all eight said they felt disconnected from their lower body, and were unable to even imagine moving their paralysed body parts. But after 1100 hours of training, everyone said they felt a sense of ownership over their limbs. "They felt that they

"One person asked to borrow the exoskeleton so he could walk down the aisle at his wedding"



BIGONSAI + LENTE VIVA FILMES

Finding her feet again

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had legs again,” says Nicoletis. “They can actually feel that they are touching the ground and moving their legs.”

But what really startled the team was that everyone showed signs of functional recovery. “In every patient we saw an improvement in tactile sensation,” says Nicoletis. Some people could feel regions of their body seven vertebrae below their spinal cord injury, and everyone could voluntarily move muscles in their lower limbs.

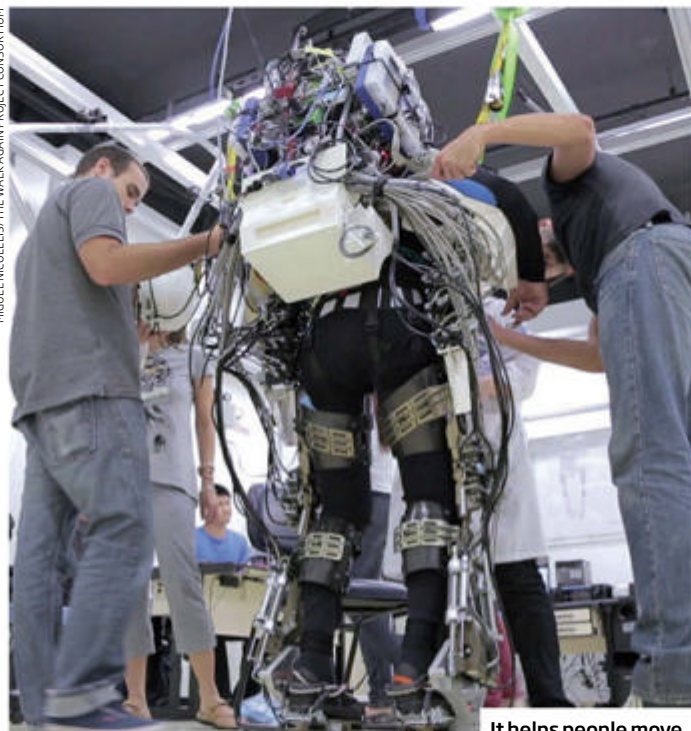
Reactivated nerves

The greatest improvement was in a woman who had received a complete spinal cord injury 13 years ago. After a year of training, she could feel sensations below her injury, and, when supported in a harness, could make leg movements associated with walking.

While the individuals are still some way from being able to support their own weight and walk unaided, their level of improvement is “dumbfounding,” says Sukhvinder Kalsi-Ryan, a physiotherapist at the University Health Network in Toronto, Canada, who trials therapies for people with spinal cord injuries. “This is the most extreme recovery I’ve ever seen,” says Kalsi-Ryan. “What Nicoletis has done is phenomenal – the patients are much closer to normal human movement.” The results are more impressive because they were seen in all eight people, she adds.

“These are important observations,” says Lee Miller, who is developing thought-controlled prostheses in monkeys at Northwestern University in Chicago. “But it’s important to temper the excitement with the recognition that it will be a long road before patients could begin to think of being able to walk independently again.”

No one is sure how tactile feedback is triggering recovery. “One of the most important factors in rehabilitation is



MIGUEL NICOLELIS/THE WALK AGAIN PROJECT CONSORTIUM

It helps people move...



...and gives tactile feedback

mimicking normal stimulation,” says Kalsi-Ryan. When nerves and other cells aren’t used, they shrink and atrophy. “Things just stop working,” she says. The feedback from the exoskeleton’s artificial skin may trick nerve cells into reactivating and regrowing. “They have created the closest thing to a human experience,” she says.

It is also unclear how people

“This is the most extreme recovery I’ve ever seen. It happening in eight people is even more impressive”

with complete injuries were able to recover to the extent observed. “Although diagnosed as having a complete injury, there must be some small remaining connection there,” says Miller. Nicoletis agrees, and argues that people with complete spinal cord injuries shouldn’t be written off in terms of recovery. “Our results suggest that we should offer rich physical therapy no matter what the original diagnosis,” he says.

The Walk Again exoskeleton is still only a prototype. The group is developing a slim-line, affordable

GET UP AND GO

Exoskeletons aren’t the only way of getting people with spinal cord injuries back on their feet.

SPINAL CORD STIMULATION

In 2012, a team at the University of Louisville in Kentucky saw impressive results when they implanted electrodes directly into the spinal cord of a paralysed man, enabling him to stand. After using the implant for seven months, he was able to move his leg and ankle.

STEM CELL IMPLANTS

Last year, a Polish man with an apparent complete spinal cord injury regained the ability to walk with a frame following an injection of neural stem cells into his spinal cord. However, many scientists remain unconvinced that his recovery had anything to do with the transplant – it may have been down to the intense physical therapy he received, they say.

PERIPHERAL NERVE STIMULATION

Electrically stimulating muscles while zapping people’s brains with magnetic fields improves muscle activity and dexterity in people with incomplete spinal cord injuries. The simultaneous stimulation mimics communication between the limbs and the brain. The approach isn’t an option for people with complete spinal injuries as they wouldn’t be able to feel the muscle stimulation.

version, and is training more people with spinal cord injuries. The wearers don’t seem to mind the clunky prototype – one asked to borrow it so he could walk down the aisle at his wedding.

Nicoletis hopes the exoskeleton could exist alongside the robotic walkers already found in many rehabilitation centres. Kalsi-Ryan says she can see the exoskeleton being more widely used for people with spinal cord injuries. “It will take a good 10 years, but I do think these things will become part of our future,” she says. ■



Who could use a lower dose?

Design your own personal placebo

Penny Sarchet

YOU'VE got a splitting migraine. If you were offered a sugar pill, would you bother taking it? What if you were told your genetic make-up means it is very likely to make you feel better?

These are some of the questions raised by the burgeoning effort to understand which genes influence the placebo effect, and how they determine someone's susceptibility to it.

There are tremendous differences in response, says Kathryn Hall of Harvard Medical School. "It can vary from no measurable response to someone getting significantly better." Having drawn together all the genetic placebo studies carried out, Hall says there is reasonable evidence for at least 11 genes that influence susceptibility.

So should genetic screening be used to assess how likely a person is to respond to a placebo, such as a sugar pill or saline injection? Doctors could use this knowledge to personalise treatments for their patients, says Luana Colloca

at the University of Maryland in Baltimore. Symptoms of conditions such as migraine, depression, irritable bowel syndrome and even Parkinson's disease seem to be relieved by placebo in some individuals. Screening for placebo responders could also help design more balanced clinical trials (*Trends in Molecular Medicine*, DOI: 10.1016/j.molmed.2015.02.009).

It's hard to know how many

people are placebo responders, but estimates put it at about a third. There is some evidence that brain imaging can identify people that fall into this category, but a genetic read-out would offer a convenient and clearly codified measure.

So far, the 11 genes implicated in the placebo response are all involved in neurotransmitter pathways. One example is a mutation in the *COMT* gene, which codes for an enzyme that breaks down dopamine. As many as a quarter of Caucasians carry two copies of the mutated gene. In 2012, Hall and her colleagues showed that this is associated with a stronger placebo response

in people with irritable bowel syndrome. When people in hospitals are given a pump to deliver their own morphine, individuals with *COMT* mutations give themselves lower doses.

This highlights how placebo genetic screening could help in the prescription of painkillers.

"There's some evidence that placebos work even if you know you are taking them"

For instance, identifying other genetic groups that respond well to a placebo could allow these people to get effective treatment with lower doses of drugs, and therefore fewer side effects.

But to use placebos clinically, doctors would be ethically bound to explain the treatments to their patients. This may not scupper the effect – there's some evidence that placebos work even if you know you are taking them (see "5 weird things about the placebo effect", below). It may come down to the words used, says Hall. "If a doctor says 'we're going to give you a drug that has very little active ingredients, but it's going to be effective', it's going to solicit a whole series of responses in your brain."

"Genetic screening may be more useful in research than in clinical routine settings," says Tomas Furmark at Uppsala University in Sweden, who discovered the first placebo-associated gene in 2008. He suggests that research trials could use screening to spread placebo-responders evenly between drug and control groups, making it easier to detect whether a treatment is effective.

But Furmark warns that in general, progress in using genetic screening techniques to inform clinical treatments has been slow. "There is still a long way to go before screening for placebo gene variants becomes meaningful, especially given the complexity of the phenomenon." ■

5 WEIRD THINGS ABOUT THE PLACEBO EFFECT

1. It doesn't have to be a secret

Some think it only works if you don't know you're taking it. But people with irritable bowel syndrome who knowingly receive a placebo do better than those left untreated.

2. It works better if it's expensive

A placebo pill's pain-killing power is greater among people told they are taking a full-price version, compared with those told the pill is discounted.

3. Animals can get it too

In a 2012 study, between 30 and

40 per cent of rats experienced pain relief when their morphine injections were swapped for saline.

4. It has an evil twin

The nocebo effect makes people more likely to suffer from side-effects if they are warned about them by their doctor.

5. Your personality could give it away

Traits like being extroverted, agreeable and open to new experiences appear to be linked with placebo susceptibility.

INSIGHT Mauna Kea controversy

Giant telescope hits a raw nerve for Hawaiians

LIKE many of her colleagues, Sarah Ballard is eager for the Thirty Meter Telescope to get up and running. With a light-collecting mirror nine times the area of the ones on the nearby twin Keck telescopes – currently the world's most powerful – the TMT will revolutionise the search for Earth-like worlds around other stars and peer to the very edge of the visible universe.

But Ballard, an astronomer at the University of Washington in Seattle, is conflicted. A group of indigenous Hawaiians are adamant that the TMT should not be built. They are incensed by the selected site atop the dormant volcano of Mauna Kea – which they consider holy. After a series of protests that have landed 31 activists in jail, Hawaii's governor, David Ige, imposed a moratorium on construction until 20 April for “further dialogue” between protesters and the telescope builders.

It's not the first time that the siting of powerful telescopes on the mountain's 4200-metre summit has upset native Hawaiians – but in the past, the rest of the world has remained largely unaware.

That's no longer the case, thanks to the #protectMaunakea hashtag on Twitter, a Facebook campaign and several blogs. “Back in the day, we had

the *LA Times* writing about us,” says Kealoha Pisciotta, part of a group suing to block the project, “but now we have social media.”

Thanks to Ballard, astronomers are aware of the issue as well. She learned about the controversy from Keolu Fox, a native Hawaiian friend who studies genomics technology at the University of Washington. Ballard posted about the issue on the Diversity in Physics and Astronomy page on Facebook, setting off a long and remarkably

sympathetic comment thread.

But the protests have taken Sandra Dawson, TMT's Hawaii community affairs manager, by surprise. “We chose a site that has no archaeological shrines, has not been the site of cultural practices, and isn't visible from holy sites,” she says. The team had hoped that meetings over the past seven years, many of which involved indigenous communities, would have made their intentions clear. “We now know that that's not the case. We're going to work harder to make that happen.”

The TMT may feel like the final straw for a people who have been treated shabbily in the past. Their



TMT

resources were exploited by Westerners, and then a US-backed coup in 1893 overthrew the Hawaiians' last queen, Lili'uokalani, leading to US annexation of the islands. “Our culture is dying,” says Fox. “By 2040, there won't be any pure Hawaiian people left on planet Earth.”

Given that history, it's perhaps not so surprising that native Hawaiians are rallying against the mountain's largest construction project to date. They also insist that the TMT does not comply with environmental regulations, a charge that forms the basis for the legal challenge to the project.

It's hard to imagine that the TMT, with a budget of more than \$1 billion and backing from a long list of major universities, will not be built eventually. But the controversy has forced astronomers to consider issues they have rarely had to confront in the past. “I'm nervous about the effects that speaking out might have on my career,” says Ballard. “But just being afraid isn't sufficient reason to stay silent.” **Michael Lemonick** ■



Consensus needs to be built, too

Females took to weapons first, say chimp hunts

WOMEN could have been the first humans to use weapons to hunt. An analysis of spear-wielding chimps, most of which are females, suggests the idea may not be as eccentric as it may sound.

In 2007, Jill Pruetz from Iowa State University in Ames discovered that chimps in Fongoli, Senegal, thrust sharpened sticks into nest holes in

trees to stab or club small, nocturnal primates called bushbabies. Pruetz and her team observed 308 such hunts up until 2014. Females carried out 61 per cent of them, despite making up only 39 per cent of the chimps in hunting parties (*Royal Society Open Science*, DOI: 10.1098/rsos.140507).

The Fongoli chimps are still the only ones known to use weapons to kill or wound prey, even though chimps elsewhere in Africa – again mainly females – use tools to get at termites and tubers. Pruetz suspects that may be because the Fongoli band is much

more cooperative than most, so female hunters are less likely to lose their kill to a bigger male. “There's no incentive to hunt if you're going to have your prey stolen,” she says.

The relative lack of prey at Fongoli's savannah habitat may have made chimps there more inventive in their quest for meat, says Travis Pickering of the University of Wisconsin at Madison. If female chimps initiated

“Maybe it should cause people to rethink the old premise of man the hunter”

the use of weapons to hunt, the same might have been true of the earliest humans, Pruetz suggests. “Maybe it should cause people to rethink the old premise of man the hunter,” she says.

Others remain sceptical, arguing that hunting in general is mainly a male activity in both chimps and most modern hunter-gatherers. That in itself doesn't exclude the possibility that men got the idea of hunting with weapons from women. “Maybe the initial inventiveness is female-based,” says Pickering. “But I don't think we'll ever be able to pin that down based on archaeological data.” Bob Holmes ■

Martian soil could hold liquid water

Jacob Aron

LIQUID water collects in the Martian soil each night, before evaporating during the day. If future missions can confirm this cycle, astronauts could one day farm moisture to provide drinking water on Mars.

Planetary scientists have seen a lot of evidence for frozen water at the Martian poles, and water vapour in the planet's atmosphere. Liquid water, on the other hand, has been harder to come by, because the temperature and

"Future astronauts could take moisture out of the atmosphere to produce liquid water"

atmospheric pressure at the surface is too low.

But the soil on Mars is known to host perchlorate salts, which lower the freezing point of water, meaning the chilly surface conditions are not an absolute barrier to liquid water.

Images from NASA's Phoenix lander in 2009 suggested it had liquid water running down one leg, but this sighting may instead have been ice, leaving the case for liquid water inconclusive.

So Javier Martin-Torres of the Luleå University of Technology in Kiruna, Sweden, and colleagues have tracked the weather conditions on Mars throughout Curiosity's first Martian year, recording humidity, air and ground temperatures with its Rover Environmental Monitoring Station (REMS).

The team found that during the Martian winter, conditions throughout the cold but humid nights would allow liquid water to persist in the first 5 centimetres of the surface. It could also

persist for shorter periods in other seasons.

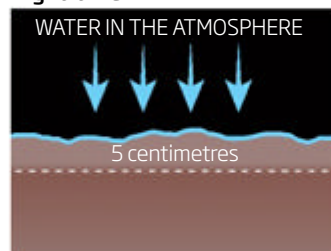
They suggest that calcium perchlorate in the ground absorbs water from the atmosphere until it dissolves into a salty solution, or brine. This process is called deliquescence (see diagram, below). When the sun comes up and the temperature rises, the water evaporates and returns to the atmosphere, starting the cycle anew (*Nature Geoscience*, doi.org/3mx).

Curiosity can't measure this water directly, says Martin-Torres, but everything is in place for it to be there. "We find the conditions for brines to be produced, but if you want to measure them directly you need some other kind of measurement," he says, such as an instrument that can look for changes in electrical conductivity.

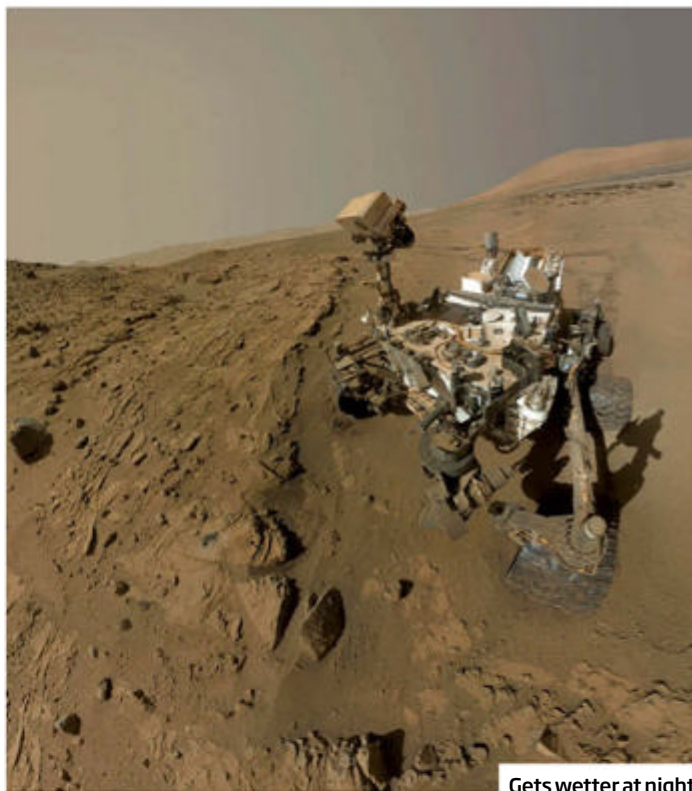
Alfonso Davila of the SETI Institute in Mountain View, California, says there is not enough evidence to be certain that there is liquid water on the current surface of Mars, but the result does indicate that the planet was previously wetter. "To me, the work is significant because it suggests that deliquescence processes could have been important in the past,

Moist Mars

Night-time



Water from the atmosphere may be absorbed by salts in the Martian soil to form brine. This lets liquid water exist just below the surface



Gets wetter at night

when there was more water in the atmosphere and the temperatures were higher," he says.

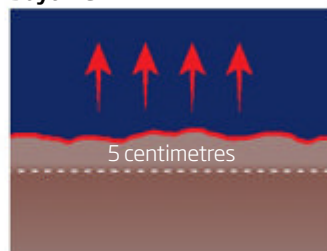
If the water is there, it's unlikely to harbour life; the temperature is below -30°C on average – too cold for even extreme Earth microbes to replicate and metabolise. "The fact that no microorganisms on Earth can grow at temperatures lower than -20°C or so suggests that this could be a hard limit for water-based life," says Davila.

"Even if conditions were

more favourable in terms of temperature and water, there are other factors near the surface – such as the high levels of radiation and oxidants – that would be severely challenging for any type of life or even organic molecules to survive," says Sam Kounaves of Tufts University in Boston, Massachusetts, who worked on the Phoenix mission.

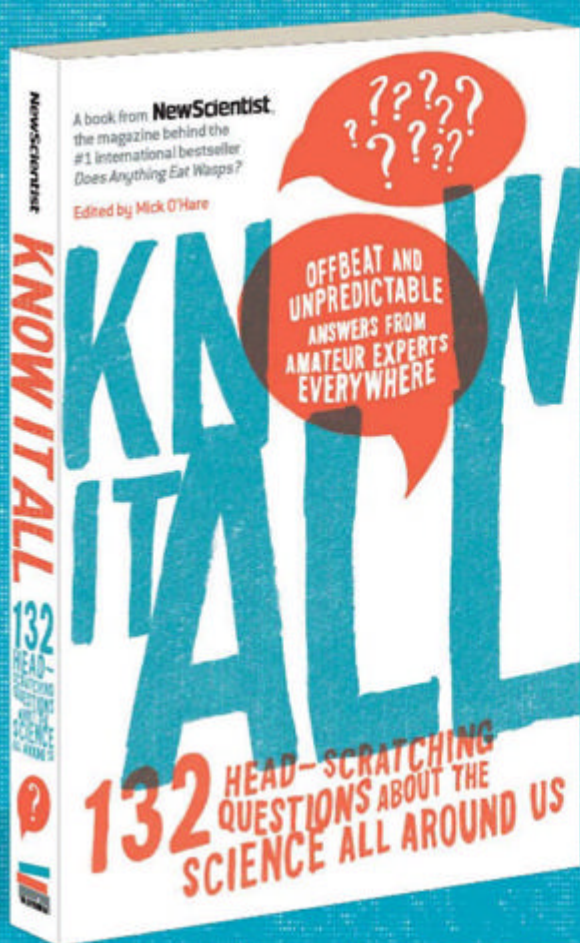
This water might one day help life flourish on Mars in other ways, however. Martin-Torres is currently working on a proposed device for the European Space Agency's ExoMars rover, due to launch in 2018, that would exploit Curiosity's findings. "It's a proof of concept of an instrument that will take water out of the atmosphere to produce liquid water for astronauts," he says. Small containers holding salts and mounted on the rover would mimic the natural deliquescence process. If it works, astronauts could do the same on a larger scale to support Mars exploration. ■

Daytime



When the sun comes up, the water would evaporate back into the atmosphere, starting the cycle again

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Neanderthal chefs spiced up their diet

Catherine Brahic

THE image of a Stone-Age man grasping the bony end of a bloody mammoth leg and chomping down on it with powerful gnashers is taking a bit of a battering. We already know that Neanderthals were partial to delicacies such as fish and small birds, with a healthy helping of plants. Now some are saying they might have flavoured their meaty

"Neanderthals were probably well versed in the art of roasting, and may have even made stew"

feasts with wild herbs, too.

Without a time machine to take us back 40,000 to 50,000 years, the suggestion remains highly speculative. But our long-lost cousins were clearly not the carnivorous beasts we once assumed them to be.

The idea that they were partial to a handful of herbs comes from the hardened plaque – or dental calculus – chipped off the teeth of a 50,000-year-old Neanderthal from El Sidrón in Spain. A few years ago, Karen Hardy of the

University of Barcelona and colleagues found traces of camomile and yarrow in the calculus – both plants with strong flavours but no nutritional value (*Naturwissenschaften*, doi.org/h33). They argued that the plants were eaten for medicinal purposes. Self-medication is common in the animal world, says Hardy, and it's very likely Neanderthals did the same.

Sabrina Krief of the French natural history museum in Paris, thinks differently, based on her observations of wild chimpanzees in Kibale National Park in Uganda. After a hunt, these chimps can eat up to three different types of leaf with their prey (*Antiquity*, doi.org/3mk). Chimps are thought to self-medicate with leaves, but Krief says some scoff leaves to spice up their food. Her rationale is that all the chimps in a group ate them at the same time, and it's unlikely that every chimp needed the same remedy. Also, different chimp tribes opt for different leaves.

If chimps flavour their food, why not Neanderthals? The palaeontologists contacted by *New Scientist* say this is possible



I'm having the Neanderthal platter

but highly theoretical. What is clear is that Neanderthals were not simple carnivores. All hominins must eat carbohydrates to survive, says Hardy. Meat just doesn't provide enough energy.

There's also a limit to the amount of animal protein we should have in our diet – too much meat is not good for us, says Hardy. So at the very least, we know that Neanderthals liked some veg with their steak – though what kind of veg is still up for debate. Remains at a site in

Gibraltar suggest they also liked nuts and wild olives.

And they clearly liked a variety of meats. Geoff Smith of the Monrepos archaeological research centre in Germany says they were more likely to eat bovids, horses and deer than larger game – mammoth and rhino were occasional treats. Signs that they broke up the bones of their game suggest that they sucked out the rich, fatty marrow, says Smith, who presented evidence for this at the Paleoanthropology Society meeting in San Francisco this week.

And what of their cooking techniques? Some Neanderthal sites have hearths, and Hardy's study showed signs of smoke from a wood fire and desiccated starches. They were probably well versed in the art of roasting.

Perhaps Neanderthals even boiled their food, boiling bones to extract the juices and nutrients, a bit like making a stew. "They may have done," says Wil Roebroeks of Leiden University in the Netherlands. "Who knows?" The trouble, says Hardy, is we've never found a Neanderthal pot. ■

PALAEO TOOTHPICKS AND GRASSY FLOSS

CANDY floss it's not, but the Neanderthals' starchy, vegetable-rich diet was not quite what the palaeo dentist ordered. It came with a healthy helping of glucose – a fabulous source of energy to power both your brain and the bacteria that live in your mouth. Dental plaque has always been a nuisance for hominins, says Karen Hardy of the University of Barcelona in Spain.

That plaque is now allowing Hardy and other researchers to study the diets of early humans in some detail.

What might Neanderthal dental hygiene have been like?

It turns out early humans were probably no strangers to the toothpick. Chimps, bonobos, orangutans, long-tailed macaques and Japanese macaques have all been seen using twigs for this purpose. And in 2013, a team wrote that grooves in the teeth of a 1.77 million year old hominin found in Georgia were probably made by a lifetime of wielding toothpicks (*PNAS*, doi.org/3mm).

Hardy says early humans are thought to have used bits of wood, bone, sinew and grass to pick and even floss between their teeth.

Their risk of tooth decay might also have been offset by a diet of wild plants. Farmed cereal grains tend to stick to the teeth more easily than wild foods, which can be very abrasive, says Amanda Henry of the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany. This suggests the palaeo diet came with its very own in-built toothbrush.



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Rounded penis and hairy balls reveal new monkey

MEET the world's newest monkey. The white-cheeked macaque, *Macaca leucogenys*, has been discovered in a remote region of south-eastern Tibet called Modog.

Chao Zhao at China's Dali University and his team set up camera traps in four Tibetan gorges that took more than 700 photos of macaques. They then compared the photos with those of four known species in the region.

The new macaque is distinguished from the others by its rounded glans penis and a dark, hairy scrotum. Other macaques in the region have a spear-shaped glans penis and a white scrotum. It also has thick, long hair around its

neck, unlike the other four species. The macaque forages in a wide range of habitats, from tropical forests at an altitude of 1400 metres to mixed forests of broad-leaves and conifers up to 2700 metres high (*American Journal of Primatology*, doi.org/3jh).

"It is an area where there's been very little scientific exploration, partly because of political conflicts," says Paul Garber, executive editor of the *American Journal of Primatology*. "The forest in Modog is like a nature library, and we know very little about it," says Zhao. "This discovery suggests that there may be some species there that still remain undiscovered."

The macaque already faces threats from hunting by local tribes and China's planned hydropower construction in the region, the team says.

Parasites make for efficient algorithms

PARASITES are nature's thieves, but we can harness this behaviour for our own gain.

We use algorithms to work out complicated problems like the best truck route or crew schedule, because finding a good solution means fiddling with the values of many parameters simultaneously.

One way they can do this is by using groups of virtual creatures that wander through "parameter

space", looking for valleys that represent the lowest values. Mathematicians have taken inspiration from actual animals, from grey wolves to ants. One limitation, though, is that the animals sometimes fail to notice a deeper valley nearby. Adding parasites can stop this from happening, say Shi Cheng of the University of Nottingham Ningbo, in China, and his colleagues.

In their model, a swarm of animals searched for the lowest valleys, but was then joined by a second, parasitic population. This group searched for valleys, but also abducted the most successful animals and made them work for the parasite team.

The result of this struggle for life was a more varied collection of creatures that enabled the parasitic algorithm to solve a problem in half the time (*Applied Soft Computing*, doi.org/3j6).

Paper microphone creates a charge

SCREAMING at your dying cellphone battery may soon do some good, thanks to a postage stamp-sized microphone that can harvest acoustic energy to top up your charge on the go.

Zhong Wang of the Georgia Institute of Technology in Atlanta and his colleagues created their microphone from a sheet of paper just a few centimetres across. They used a laser to zap a grid of microscopic holes in the paper, coated one side in copper and laid it on top of a thin sheet of Teflon, joining the two sheets at one edge.

Sound waves vibrate the two sheets in different ways, causing them to come in and out of contact. This generates an electric charge, similar to the one made when you rub a balloon on your hair, which can charge a phone slowly. It can also be converted into a range of sound frequencies, using the sheets as a microphone (*ACS Nano*, doi.org/3j3).

Knuckle cracking caught on camera

DOES the sound of cracking knuckles make you flinch? What about a film of the joints in action? Now MRI scans have captured the moment your joints go pop.

Gregory Kawchuk at the University of Alberta, Canada, used a cable to slowly pull a man's fingers in an MRI scanner until the joints cracked. It was thought the sound came from the collapse of an air bubble, but the scans showed the air cavity that formed in the fluid around the joint persisted after the noise.

A mysterious flash was also seen just before the crack. It may be caused by cartilage releasing fluid as tension on the joints rises. Higher-resolution MRI might shed more light (*PLoS One*, DOI: 10.1371/journal.pone.0119470).

Lucy had a bit of the baboon touch

IT WAS a piece from another jigsaw. A stray baboon bone has gone undetected despite more than 40 years of scrutiny of what's arguably the most famous early human fossil.

Found in 1974 near Hadar village in Ethiopia, Lucy is the fragmented skeleton of an *Australopithecus afarensis* species dating back 3.2 million years. Mike Smith at the American Museum of Natural History in New York recently noticed that one of the spinal bones looked out of place. "It was just too small," says Scott Williams at New York University, who took a closer look with Marc Meyer at Chaffey College in Rancho Cucamonga, California.

They compared the bones with other *Australopithecus* fossils and those of animals alive at the same time, such as porcupines and pigs. "Baboons were a close match, both in shape and size," says Williams. "So we think we've solved this mystery."

They have also confirmed that the other 88 fragments in Lucy's skeleton are correctly identified, says Williams, who presented the work at the Paleoanthropology Society's meeting in San Francisco this week. The rogue bone might have evaded discovery for so long because most experts have focused on studying limb bones, says Dan Gebro at Northern Illinois University in DeKalb.



PPL/ALIVE DANNES/SCIENCE PHOTO LIBRARY

Smartphone holograms could help detect cancer

A SELFIE might save your life. The camera on your phone could be used to test for cervical cancer and HPV, a virus that can lead to the disease.

Diagnosing disease is costly and time-consuming. Ralph Weissleder of Massachusetts General Hospital, Boston, reckons digital holography – the construction of 3D images of cells using a smartphone-compatible device – could help.

To turn holography into a diagnostic tool, Weissleder's team first had to make different cells,

such as those collected during a smear or pap test, diffract light differently. They did this by adding microbeads, which bind to specific molecules – such as cancer markers or HPV DNA – and change their diffraction pattern.

They then inserted the sample into a device that clips on to any smartphone. Light is shone on to the sample and patterns of diffracted light are detected by the phone's camera. These are sent to a computer that reconstructs an image of the cells present. This image is sent back to the phone,

along with the result. The process costs \$1.80 and takes 45 minutes.

The device was able to distinguish between women who were at high or low risk of cervical cancer and to detect the presence of HPV as accurately as conventional tests (*PNAS*, DOI: 10.1073/pnas.1501815112).

Later iterations of the device that detect patterns in a spot of blood from a pricked finger could be used by women at home, says team member Cesar Castro. "The user would get an image and an analysis of the results."

Gorillas OK despite ancestor incest

APES could be aided by the incest of their ancestors. Only about 800 mountain gorillas remain in the wild, so the odds of inbreeding and inheriting harmful mutations are high. But it seems their number has been low for so long that they may have already weathered the genetic storm.

Aylwyn Scally of the University of Cambridge and his team sequenced the complete genomes of seven mountain gorillas. The researchers found the gorillas were even more inbred than they expected, roughly equivalent to the offspring of a great-uncle and great-niece (*Science*, doi.org/3jb). "It's more inbreeding than we've seen so far in any other great ape," says Scally.

But they also carried fewer of the most harmful mutations than western lowland gorillas, their more numerous cousins. This may be because mountain gorilla populations plummeted about 100,000 years ago and have had a long time to purge their genomes.

If so, conservationists may have one less problem to worry about. "There's no reason to suspect that mountain gorillas have gone past some genetic point of no return," says Scally.



AGEFOTOSTOCK/GETTY

To regrow hair, pluck out what's left

LOSING your hair? Paradoxically, the answer to growing it back might be to pluck a lot of it out.

Baldness sets in when hair follicles stop generating new hairs. People have known for almost a century that plucking a hair can reawaken its follicle. But replacing hairs one by one is little use if you're going bald.

A team led by Cheng-Ming Chuong of the University of Southern California in Los Angeles has found that if you pluck out enough hairs in mice, it triggers widespread regrowth. The skin sees one plucked hair as a microinjury and sends out a distress

signal that triggers the follicle to regenerate. But pluck enough and the strength of the signal triggers regeneration in undisturbed follicles too. Chuong says this coordinated decision happens via "quorum sensing", a type of communication also used by bacteria (*Cell*, doi.org/3jj).

Will it work in humans? "That's the 6-million-dollar question," says Nadia Rosenthal from Monash University in Melbourne, Australia. She says that unlike humans, mice grow hair in waves, which means their follicles may already have a propensity to coordinate.

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A drone that learns

Smart drones that can learn and think like animals could herald the start of delivery services and crop monitoring, says **David Hambling**

THAT drone buzzing round your head might be smarter than you think. Small drones with neural hardware resembling brains will soon share airspace with other aircraft, seeing and avoiding potential hazards autonomously. The ability will help drones take on a host of new roles.

Big firms like Amazon, DHL and Google are developing their own drone fleets for rapid delivery of consumer goods, fast food and pharmaceuticals. However, current rules restrict drones to flying within visual range of a human operator because of the risk of collision. Drones need an automatic “sense-and-avoid” capacity before they will be able to make deliveries on their own.

Computers capable of recognising objects in video and responding in real time are too big and too power-hungry for small drones. That means drones have to rely on short-range sensors like radar, which may not give enough warning to avoid a collision.

The key may be to mimic how animal brains work; our brains are

This capability forms the basis of a learning system that mimics neurons and the connections between them. A chip-sized neural system linked to the drone’s existing camera can be trained to recognise aircraft and other hazards at long range. Bio Inspired’s drone should be ready for its first flight later this year.

The system can also recognise objects like clouds, birds, buildings and radio towers, and uses visual cues to estimate how far away the objects are.

“Objects like other aircraft can be catalogued in a vague sense, meaning ‘I see an aircraft’, or in

an exact sense: ‘I see another drone’,” says Terry Gafron, CEO of Bio Inspired.

Equipped with this information, the drone plots a new flight path to avoid a hazard, updating it in real time as the threat moves.

“Nature seems to use this approach very effectively,” says David Warne of Queensland University of Technology in Australia, who has worked with artificial neural networks that let drones recognise vegetation.

Like others in this area, much of Bio Inspired’s research has been funded by the military. But it is likely that it will benefit the wider

market. Sense-and-avoid will make it possible for fleets of small drones to criss-cross cities delivering packages. Like a bird or insect, a neural-enabled drone could fly to the trickiest landing place – even balconies.

Being able to recognise objects autonomously will enable a range of applications for small drones. Some of these are in the area of precision agriculture.

“The crop drone is on everyone’s short list,” says Gafron. Drones could survey a farm, recognise areas where crops aren’t thriving and move in for a closer view to establish whether the field needs water, fertiliser or fungicide.

In the industrial field, neural drones could patrol pipelines looking for leaks, or identify electrical faults on power lines.

Closer to home, smart drones could clean windows, pick up litter, clear gutters or weed your garden, or send information to your car about which parking spaces are open. “It simply flies around town monitoring parking spaces,” says Gafron.

Smart drones could even track animal populations, flying along livestock boundaries to track wolf populations for example. “Not only could the system fly autonomously, but it could conceivably tell the difference between a deer and a wolf from the air,” Gafron says.

Memristor-inspired drones are not the only approach. Last year, US agency DARPA unveiled the TrueNorth neural chip developed in conjunction with IBM. This is a simulation of a neural network using digital hardware with enough neurons to match agile flyers like bees. ■

“Like a bird, a neural-enabled drone could fly to the trickiest landing place – even balconies”

poor at number-crunching but can process complex sensory input faster than digital systems.

Bio Inspired Technologies of Boise, Idaho, is doing just that. It is building a sense-and-avoid system using a memristor, a resistor with a memory. Like the synapse in a biological brain, the memristor changes when impulses pass through it. Crucially, it is able to remember the impulse after it has stopped.



Needs more fertiliser

67PHOTO/ALAMY

INSIGHT Earthquake warning



JUSTIN SULLIVAN/GETTY IMAGES

Every second counts

Run, a quake's on its way!

Smartphones are ideal for sounding the alarm, finds **Aviva Rutkin**

ONE day last August, in the early hours of the morning, an earthquake of magnitude 6.0 rocked Napa Valley, waking people all around California's famed wine region. Many were wearing Jawbone fitness trackers that monitor their sleep. Once the quake was over, Jawbone published a graphic detailing the differences in disturbance for lifeloggers in Berkeley, Oakland and San Jose.

While the post didn't inspire confidence in the privacy of users' data, it did make a point: humans can be useful sensors. We are laden with devices that track our movements and interests – data that seismologists want to mine to help them spot the next major earthquake as it happens.

At the US Geological Survey, Benjamin Brooks is looking at smartphones, which come equipped with GPS sensors that can tell where you're standing, give or take a few metres. Their sensors can also detect a sudden lurch in one direction – the kind of movement that might be a sign of a seismic shift when logged by many people at once.

"Imagine all of Portland was out at a cafe on a sunny day, and everyone's smartphones were sitting on the table

when one of these great earthquakes happened," says Brooks. "The whole city would appear to move."

Brooks and his colleagues have now tested what crowdsourced GPS data might look like in a real earthquake. One simulation explored a model magnitude 7.0 earthquake along the Hayward fault on the east side of the San Francisco Bay, and another used

"Phones can sense a sudden lurch in one direction – the kind of movement that might be a seismic shift"

location data recorded at scientific stations during Japan's devastating megaquake in 2011.

Both scenarios suggested that data from around 5000 people would be enough to spot the beginnings of a major earthquake, leaving about 5 seconds to warn major population centres that hadn't yet felt its effects (*Science Advances*, doi.org/3mg).

When a quake is coming, even a few seconds of warning can be crucial. Fire-station doors could start to raise, gas pipelines could automatically shut off and city residents could jump to safety under a nearby desk.

Next, Brooks and his colleagues plan to keep putting smartphones to the test. In an upcoming pilot in Chile, about 250 phones will be placed in boxes around the country, where they'll lie in wait to record the next big earthquake.

Others have found different ways to tap into human activity to locate quakes. At the European-Mediterranean Seismological Center in Strasbourg, France, seismologists rely on the internet to pinpoint where earthquakes are happening around the globe.

Whenever there's a sudden surge of traffic to their website, they look at where visitors are accessing it from to get a sense of where the earthquake is and how strong it might be. They also monitor Twitter for relevant keywords. Within a couple of minutes, they have enough information to publish their first unconfirmed reports of the quake.

"The internet is the nervous system of the planet," says Rémy Bossu, secretary general at the centre. "If we want to make rapid earthquake information available to the public and authorities, we have to focus on the earthquakes that matter for them." ■

The perfect app launcher for when things get hairy

IS THAT woman absent-mindedly stroking her hair? Or is she logging her location? She just might be, thanks to a system that turns hair into a discreet launcher for your apps.

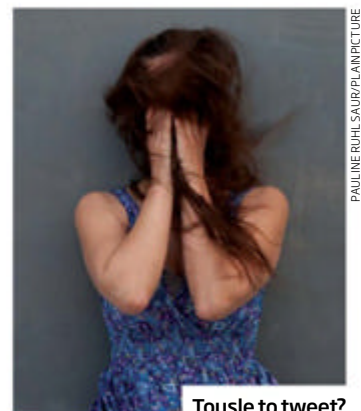
Called Hairware, it was invented by Katia Vega of the Pontifical Catholic University of Rio de Janeiro, Brazil. By plaiting conductive filaments into natural-looking hair extensions, Vega and her colleagues created a wearable switch: stroking it once activates a preselected app, twice launches another.

An Arduino microcontroller and a bluetooth radio in a hairclip provide the system's intelligence and connectivity. The result is app control that's "a mix between magic and James Bond", says Vega.

Vega says that a woman who is feeling threatened could, for example, use it to broadcast her location or send a preset emergency text message, all without visibly using a smartphone. She revealed Hairware last month at the IUI 2015 user interface conference in Atlanta, Georgia.

Vega hopes to commercialise the system and suspects that intelligence agencies might be interested. She also plans to extend Hairware by turning beards into app controllers too. "It could involve connecting a conductive beard to a clip hidden on the back of a shirt collar," she says.

Paul Marks ■



PAULINE RUHL SAUR/PLANIPICTURE

Tousle to tweet?

Deep inside Fukushima

Robots with cameras are investigating the nuclear plant's wreckage

IN THE dark abandoned shell of Fukushima Daiichi nuclear power plant, Rosemary and Sakura shoot what looks like a dystopian first-person shooter game. Rosemary scans her environment, while Sakura records every move.

But this is no traditional film crew. Rosemary and Sakura are robots operated by Tepco, the firm running the plant that went into meltdown following the March 2011 earthquake and tsunami. Using radiation-sensing cameras they perform surveys in areas where radiation levels are still too high for humans to safely enter. The data the robots collect will help plan how to decommission the plant.

Tepco has recently had problems with robots. On 10 April, it sent a robot inside the primary containment vessel of reactor 1 to measure radiation levels and investigate the condition of the melted fuel. But the robot stopped working on its first inspection and had to be abandoned. Radiation levels as high as 5150 millisieverts



Enter Sakura

per hour have been detected in the basement of reactor 1.

Developed at the Chiba Institute of Technology, Rosemary and Sakura can climb 45 degree slopes and use gyroscopes and other sensors to navigate inside buildings without the need for GPS. But the standard radiation detector, gamma cameras weighing 150 kilograms, proved too cumbersome for them to use.

So the team has turned to a gamma camera that weighs just

17 kilograms and can rotate 360 degrees. This has been added to the robots as part of a system called N-Visage, which also includes a laser scanner that draws a 3D image of its environment.

The radiation measurements can be combined with a laser scan of the plant's exact layout, says Trevor Craig of UK start-up Createc, which developed N-Visage for Japan's International Research Institute for Nuclear Decommissioning, and reactor maker Hitachi. An earlier version was used in Sellafield in Cumbria.

Rosemary operates N-Visage, while Sakura acts as a wireless transmission station, feeding the data to human operators located

"Rosemary and Sakura can perform surveys in areas where radiation levels are too high for humans"

in the plant's seismic-proof centre 200 metres away. They also get a fisheye view via cameras attached to the two robots.

In addition to creating real-time maps of radiation levels, the associated software can also predict how they will evolve as the facility is modified or taken apart. "Once we have a model like this we can play scenarios to find out what happens to dose rates if we decontaminate this wall, or put shielding next to highly contaminated fuel handling machinery," says Craig. "It helps work out what the decommissioning plan should be."

To date the N-Visage system has been used in the first three reactors at Fukushima. Createc is adapting the technology for use inside a snake-arm robot to delve even deeper into the reactors in an attempt to discover exactly where the fuel ended up. **Rob Gilhooly** ■



Radiation threat

ONE PER CENT



Find yourself at Hajj

Even religion can't escape wearable tech. Pakistani start-up Hajj Guider has created a smart bracelet for Muslims on pilgrimage to Mecca. The bracelets track the wearer's location with GPS and Bluetooth. An app lets people see where their family is in the crowd, send messages to one another and look up how to perform religious rituals. It will also give updates on emergencies like stampedes.

"Governments have been lobbied into experimenting recklessly with the functioning of the internet"

Joe McNamee, executive director of European Digital Rights, helps launch the Save the Internet campaign, ahead of EU meetings to discuss whether paid-for fast lanes for internet traffic should be allowed.

Riot drones

Here's a drone we aren't looking forward to. Police in the Indian city of Lucknow say they have tested a drone that can pepper-spray disorderly crowds. Each has high-resolution cameras and can carry about 2 kilograms of pepper spray. The city police, who now own five drones, have already used them to keep watch on religious festivals.

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Sweet chile of mine

HE MAY look soft and furry - but don't be fooled. "Out of all the species of bees that I've photographed during this project, this little guy was the only one that actually looked up at me and bared its mandibles," says photographer Clay Bolt.

Bolt has set himself the task of documenting every native North American bee. The project was borne out of the realisation that one species - *Apis mellifera* - was grabbing the limelight in US coverage of colony collapse disorder, and it wasn't even a native bee. There are nearly 4000 more, from the rusty-patched bumble bee to this one, called the "fuzzy-legged" leafcutter bee (*Megachile melanophaea*).

Female leafcutter bees chew small circles from the edge of leaves, and use these to form tubular cells. Into each tube, she deposits a ball of pollen and an egg. The larva will feed on the pollen when it hatches.

And the flamboyant gold leg manes? "Some males in this group have very furry front legs, which are used to cover the eyes of females during mating," says Bolt. He speculates that this is to stop the females being distracted by other males during copulation. Catherine Brahic



NEIL LOSIN/DAY'S EDGE PRODUCTIONS

Photographer

Clay Bolt claybolt.com
www.beautifulbees.org

Collision course

A \$70 trillion plan for roads and other infrastructure in developing countries is a disaster in the making, warns **William Laurance**

IN THE past decade, two-thirds of the world's forest elephants – found only in the rainforests of equatorial Africa – have been slaughtered by ivory poachers.

Why this explosion in killing? Since 2000, more than 50,000 kilometres of roads have been bulldozed into this area, mostly by loggers, inadvertently opening it up to poachers armed with powerful rifles and cable snares. The elephants simply have nowhere to hide any more.

All around the world such ecological carnage is being repeated. The last remnants of nature are in retreat – and roads and other infrastructure are often the root cause.

In the Amazon and adjoining Andes mountains, 150 major hydroelectric dams are planned, each requiring a road network for dam and power-line construction. Just the 12 projects proposed for



the Tapajós river – one of the biologically richest regions – will lead to the loss of 10,000 square kilometres of forest by 2032, says a recent study.

The Amazon also has 53,000 active mining leases. New roads for mining and fossil-fuel projects are opening it up like a flayed fish, and with it a Pandora's box of environmental problems, such as illegal deforestation and fires, poaching, illicit gold mining and rampant land speculation.

And if you want to see the wilds of Africa, don't delay. They are being transformed by a frenzy of foreign mining investment. China is pouring in more than \$100 billion per year, with India, Brazil, Canada, the US and Australia not far behind. Roads and infrastructure are rapidly proliferating, including 29 massive "development corridors" that will criss-cross sub-Saharan Africa,

Borderline decisions

Africa's protected parks must not be redrawn to make way for oil rigs, says **Curtis Abraham**

A DRAMATIC drop in oil prices has done little to deter the frantic hunt for fresh reserves by foreign companies in sub-Saharan Africa.

The Democratic Republic of the Congo is a prime target. In March the government announced that it was in talks with UNESCO about redrawing the borders of Virunga National Park to allow exploration,

after the discovery of oil and gas there. The park is a World Heritage Site, home to hundreds of rare mountain gorillas and other endangered wildlife.

Redrawing borders would be a backward step. Lake Edward, in the area that would be most affected, provides more than 50,000 people with fresh water,

food and jobs. They are aware of the potential for accidents and are rightly nervous that the lake's fragile ecosystem will be ruined. There's much that can go wrong, including water, soil and air pollution from pipeline leaks, oil spills, gas flaring, dumping and sabotage. We need look no further than the mess Royal Dutch Shell made in Nigeria's Niger Delta for evidence of this. Oil trade in the area might also worsen and be vulnerable to armed rebel activity.

"Better standards of living promised via income from oil and gas extraction rarely materialise in Africa"

"The necessity is to find a middle ground to preserve nature, but also to gain profit from resources so the communities living there can see their living conditions get better," the country's prime minister, Matata Ponyo, told the BBC. But Virunga is, in principle, non-negotiable. UNESCO has said that oil and gas exploration is not compatible with World Heritage status.

In addition, better standards of living promised via income from oil and gas extraction rarely materialise in Africa and most communities end up worse off than before. Oil won't provide many jobs for residents or a

opening up many wild and semi-wild areas to new pressures.

If this seems scary, just wait a few years. At a recent summit in Australia, the G20 nations – the largest economies on the planet – pledged \$60-70 trillion of infrastructure funding worldwide over the next 15 years. To put that in perspective, the estimated value of all existing infrastructure is around \$50 trillion.

These are scary times for the environment. In my view, the G20 pledge is far too ambitious and should be scaled back sharply. Beyond this, the projects that do proceed must be managed very carefully. My colleagues and I recently published guidelines to make development ecologically safer (*Current Biology*, doi.org/2rw). Ideas include “island” projects without roads, where people and kit are flown in, curbing road building.

Let’s hope the G20 listens. No one is saying better infrastructure is not needed, especially in poorer nations trying to raise living and social standards. But the blast-ahead, business-as-usual model isn’t working. For our natural world, it threatens a fatal future. ■

William Laurance is a distinguished research professor at James Cook University in Cairns, Australia

significant boost to the local economy.

Instead, investment in fishing, renewable energy and eco-tourism could bring annual gains of \$1.1 billion and generate 45,000 jobs, according to a study by conservation group WWF.

The best option for Virunga is not to redraw borders, but to cancel all oil permits overlapping the park and to support local initiatives that are environmentally and culturally sound and that could help defuse conflict in the region. ■

Curtis Abraham is a writer based in Kampala, Uganda

ONE MINUTE INTERVIEW

Jungle boogie

Is music universal? **Stephen McAdams** played movie tunes to Mbenzélé pygmies in the Congo rainforest to find out



PROFILE

Stephen McAdams is professor of music research at Schulich School of Music at McGill University in Montreal, Canada, and also Canada Research Chair in Music Perception and Cognition. His research is published in *Frontiers in Psychology*

Why do you want to know whether music has the same effect on everyone?

Every culture has music, so if we want to understand humans, we need to understand why music is there and why it is used in different ways. Deciphering what aspects of it are dependent on our basic biology and what aspects are dependent on culture will help us find answers to these questions.

You played movie tunes to Mbenzélé pygmies in the Congo rainforest. Why them?

Their exposure to Western music was nil: they are hunter-gatherers who live in the forest. They rarely go into big cities and they don't have radios.

You also played the tunes to a group of Canadians. So is music a universal language?

In some ways, yes. Emotional arousal was the same in both groups – a reflection of whether the music was exciting or restful. That was assessed subjectively by the listeners, and objectively by measuring heart rate, breathing and so on. This

common response is probably driven by certain acoustic properties, such as tempo.

Why would some elements of music do this?

Arousal is probably linked in evolutionary terms to preparation to deal with a threat or new situation. When music accelerates or suddenly gets shrieky, for example, it seems to cue this alert response – the heart rate rises and so on.

What aspects of the music did not prompt a universal response?

We looked at whether the music evoked happy/joyful or sad/scary feelings, and got a positive/negative rating. We used music from three films: the melancholy theme from *Schindler's List*, the scary shower scene from *Psycho* and the upbeat Cantina scene tune from *Star Wars*. The Canadians reacted as you might expect. For the pygmies, we got no clear physiological results and subjectively, they found all the music negative.

Why might the Mbenzélé not like the Western music?

All the pygmies' own music is highly arousing and positive. They feel negative emotions disrupt the harmony of the forest and they depend on the forest and so they want it to be happy.

What is the Mbenzélé's own music like?

Mostly vocal, with some clapping and beating on log drums, but of a sophistication that is comparable to Western symphonic music, with extraordinary polyphonies and polyrhythms.

Did they have a favourite movie tune?

Music for them is functional – they don't sit around and consume it. Music accompanies various kinds of activities. I don't think the idea of having a favourite would make sense to them.

Did the field work in Congo go smoothly?

For the pygmies, if you can't dance to it, it's not music. It took some persuading to get them to sit still for the research.

Interview by Jon White



The unexpected origin of human values

Why do different groups have vastly different views of right and wrong? Take a step back and the real force driving our morals becomes clear, says archaeologist **Ian Morris**

“NEVER work with children or animals,” the saying goes. Fortunately for science, Sarah Brosnan didn’t listen. Plenty of researchers had already trained primates to earn snacks by performing simple tasks; but what would happen, Brosnan asked, if she paid some subjects better than others?

The capuchin monkeys in the Yerkes National Primate Center quickly learned that when Brosnan gave them a granite pebble, they could get a slice of cucumber by returning the pebble to her. To a few monkeys, though, she gave a better reward: a tasty grape. Seeing their undeserving colleagues earning higher wages for the same work, some monkeys sulked and refused to eat their cucumber. Others flew into a rage, hurling the vegetable back at the biologist. It’s just not fair, they seemed to be telling Brosnan.

The experiment implied that monkeys have an innate sense of fairness. Encouraged, Brosnan extended her research to chimpanzees and human children. Her work seemed to show that all primates have moral values of some kind.

But how did these values develop? Biologists and psychologists are increasingly suggesting that human values are an evolved adaptation—one which functions, in part, to maximise the likelihood that their bearers will pass genes on to the next generation. That would explain why virtually everyone in the world has a sense of right and wrong.

What it wouldn’t explain, though, is why we humans disagree so much over what counts as right or wrong. If you were an anthropologist studying the Hadza people in northern Tanzania, for instance, you would discover

that your hosts think it right and proper that women and men should be equally free to pursue sexual partners. If you moved just 100 miles to live with the Nyamwezi people, you would find that your new hosts consider such behaviour anything but right and proper. How can there be such cross-cultural variety in human values if they are biologically evolved? Have the anthropologists got it wrong? Or the primatologists?

I suggest that neither group is wrong: it is just that scholars cataloguing human values have stood too close to their object of study, making it difficult to see the forest for the trees. We need to back away from the details of Hadza and Nyamwezi life—so far that we can see not only the whole planet, but also the full 20,000 years that have elapsed since the coldest point of the last ice age. When we do



PROFILE

Ian Morris is a historian and archaeologist at Stanford University, California. This essay is based on ideas from his new book *Foragers, farmers and fossil fuels: How human values evolve* (Princeton University Press)

Groups living just 100 miles apart can have opposite views of morality

The good news, though, is that on almost every point where archaeology allows us to compare prehistoric and modern foragers, the similarities outweigh the differences. It seems that many aspects of foraging life have probably changed little since the ice age.

No two modern foraging bands are identical, but virtually all agree that a fair world is one where everyone is treated more or less the same. No one should be much richer than anyone else or much more politically powerful; and men and women should have roughly equal freedom to do what they think best. Upstarts who subvert these values will be cut down to size with mockery, ostracism and even violence. A !Kung San forager in the Kalahari desert, asked by the anthropologist Richard Lee about chiefs, put it best: "Of course we have headmen! In fact, we're all headmen... Each one of us is headman over himself."

The second moral system, which I call farming values because it is associated with societies that support themselves primarily with domesticated plants and animals, could not be more different. Farming was invented around 9500 BC in what we now call the Middle East, and by AD 1500 it had taken over every usable niche in the world. For more than 5000 years, almost everyone on Earth belonged to a farming society. Virtually all these groups operated on the principle that a fair society was not one where all were treated more or less the same; rather, it was one where different individuals were treated differently. Some were wiser and more virtuous than others, and deserved to be rich and powerful. It was right to own slaves, for women to defer to men and everyone to defer to rulers who had been chosen by the gods – or actually were gods – because people who were male, free and royal were better than people who were not. Hierarchy was fair.

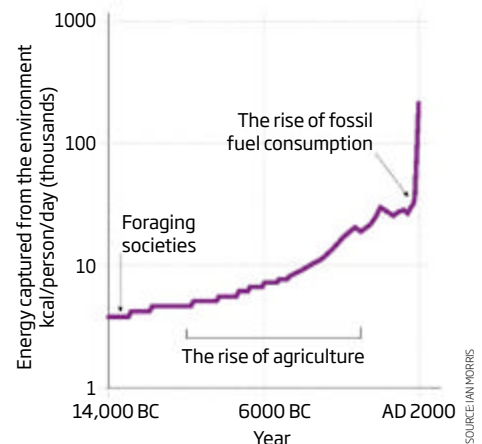
Studying farmers' values raises just as many problems as studying foragers', but this time not because we lack evidence. The historical record is enormous; what makes the job tricky

"It was right to own slaves and to defer to rulers who were chosen by the gods"

is that nearly all of our written sources were penned by small groups of elite males near the top of the pecking order. It is hardly surprising that such men thought hierarchy was valuable; but what about the women, serfs and slaves at the bottom of the pile?

Energy-hungry humanity

The amount of energy that humans extract from the environment has risen since our hunter-gatherer days, and the average American today burns through 46 times as much as a forager



Here the anthropology of modern peasant societies partly comes to the rescue. What the downtrodden disagree with, ethnographers find, is not hierarchy as such, but their own place in it, or the suspicion that their so-called "betters" are not living up to their moral obligations. Resisting specific husbands, masters or lords who are abusing their authority is right and proper; resisting authority itself is not. And we find similar attitudes even in texts from now-vanished farming societies. "The Tsar is good, but the boyars [local elites] are bad," a typical Russian peasant saying went; rebellion was justified if its goal was to let the tsar know that his agents were failing him, but not if it intended to challenge the divinely appointed tsar himself.

The third moral system is once again wildly different. I call this fossil-fuel values, because it is associated with societies that augment the energy they can extract from living plants and animals with that from fossilised plants, by burning coal and oil to power machines.

Fossil-fuel society began in Britain around AD 1800 and spread rapidly around the world. As it did so, farming values simply collapsed. Opinion pollsters tell us that by the 2010s, huge majorities – varying only slightly with age, sex, religion and nationality – were insisting that political, economic and gender inequalities are bad. Steep hierarchies, say fossil fuellers, are not fair, and people who disagree seem as immoral as democrats, socialists and feminists would have done 1000 years ago.

So is everything relative? Is the mind

that, the chaos of detail simplifies into three broad systems of values; and when we ask what explains the systems, we get an answer that unites moral philosophy with primatology.

I call the first of the three systems foraging values, because it is associated with societies that support themselves primarily by hunting and gathering wild plants. For tens of thousands of years, everyone on Earth lived this way, but now barely one person in a million does so. This presents a problem: archaeologists cannot dig up morality, so we have to extrapolate forager values from the handful of modern examples. Worse still, modern foragers have been shoved on to lands that no one else wants, and must differ in many ways from their prehistoric brethren, who had the run of the most fertile spots.

really a blank slate, on which we can write whatever story we want? No.

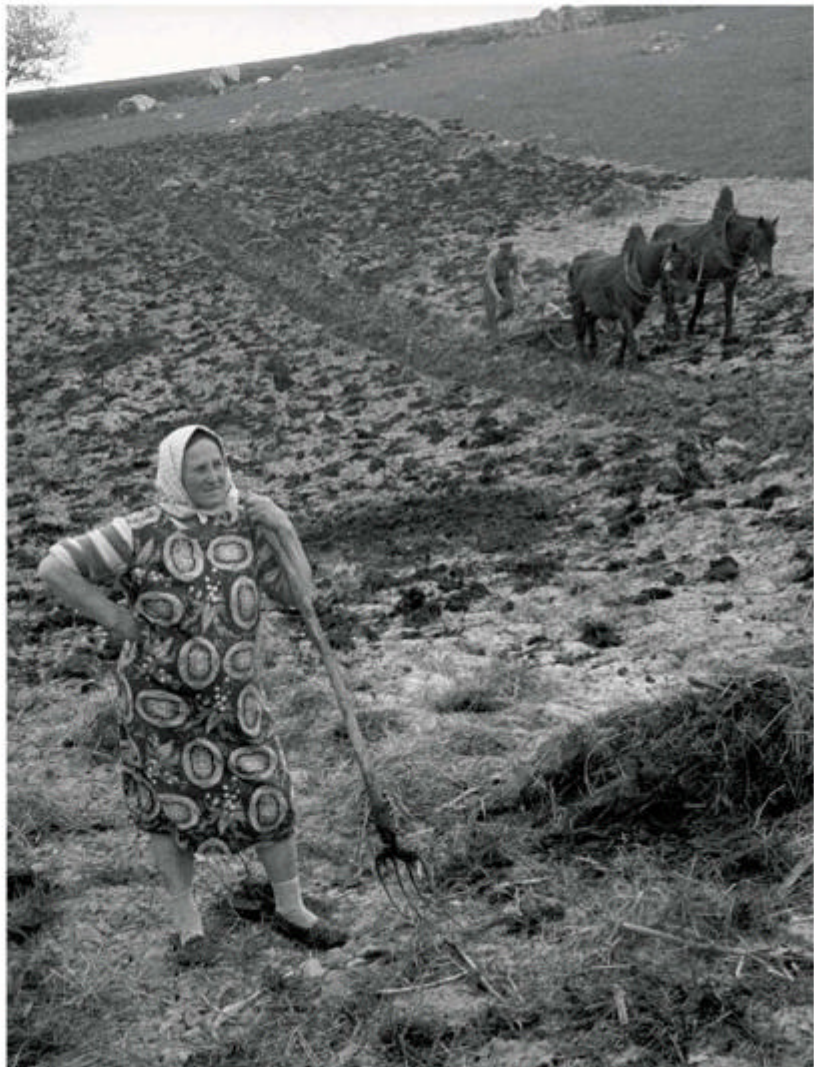
Forty years ago, the naturalist E. O. Wilson suggested that “the time has come for ethics to be removed temporarily from the hands of philosophers and biologicized”. It may not be the prettiest word in the dictionary, but biologicization is exactly what we need here.

Cultural evolution

Somewhere between 50,000 and 150,000 years ago, evolution put a kilogram of magic inside each human’s skull. The 22 billion neurons that make up the brain gave us the intellectual wherewithal to invent culture – that cumulative body of information we acquire through teaching, imitation and other transmission. With minor exceptions, humans are the only animals that have culture, and we are therefore unique in our ability to respond to environmental changes by evolving culturally, rather than waiting millions of years to evolve biologically into new creatures. Cultural evolution cannot change our biological hardwiring to make us stop believing that fairness and justice are important: but it can change what we think fairness and justice mean.

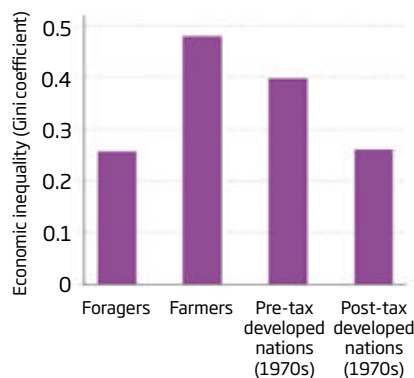
This, I suggest, is exactly what has happened across the last 20,000 years. Modern humans evolved largely in ice-age conditions, moving around constantly in pursuit of ripening plants and migrating animals. Foragers captured very little energy from the world – typically, no more than 5000 kilocalories per person per day, to use as food or fuel – and they had to live in tiny bands, usually less than 10 people strong. This made it impossible to create steep political, wealth or gender hierarchies; which, in turn, meant that those who interpreted fairness as treating everyone roughly the same tended to do well, while those whose idea of fairness was treating people differently did not. A competitive, evolutionary process pushed people towards foraging values.

That stopped when the world warmed up at the end of the ice age, making farming possible. Shifting from foraging to farming had many drawbacks. Farmers generally worked longer hours than foragers, ate more monotonous diets, had poorer health and died younger. The upside of farming, though, was that it unleashed a flood of energy: by my calculations, the amount of energy used per person roughly doubled between 10,000 BC and 4000 BC, to reach 10,000 kilocalories a day (see “Energy-hungry humanity”, page 29).



Inequality through the ages

Economic inequality changes dramatically between types of societies. One measure is the Gini coefficient. A score of 0 would mean total equality, 1 would mean total inequality



SOURCE: IAN MORRIS

By 1 BC it had risen to 30,000 kilocalories a day. As this happened, farmers turned much of the extra energy into more of their own kind. In 10,000 BC, there were no farmers on Earth, but there were about 5 million foragers; by 1 BC, there were 250 million peasants, who had driven the few surviving foragers on to lands the farmers did not want.

By that point, the biggest city – Rome – had 1 million residents. To feed itself, it drew in food from all over the Mediterranean, creating a hugely complex division of labour – one that simply could not be sustained without elaborate hierarchies, reaching all the way down to the individual household. One result was that economic inequality exploded. Using the Gini coefficient, a simple index scoring a society from 0, meaning everyone has exactly the same, to 1, meaning that one person has everything, the average foraging society



LEFT, JOSEF KOUDELKA/MAGNUM PHOTOS. RIGHT, MILLENNIUM IMAGES, UK/LAURA LIVERANI

scored 0.25 for income equality (see “Inequality through the ages”, left). The average farming society scored 0.48, and 18th-century France managed an astonishing 0.59.

Steep political, wealth and gender hierarchies became not just possible but necessary, reversing the selective pressures on moral values that had existed in the foraging world. In the age of farming, people who interpreted justice as treating people differently tended to do well; those who interpreted it to mean treating everyone roughly the same did not.

The industrial revolution increased energy capture even more dramatically. Around AD 1700, the average north-west European used about 32,000 kilocalories a day, but by 1900 this had nearly tripled, to 92,000. Today, the average American burns through 230,000 kilocalories a day. Once again, we turned a

flood of energy into more of ourselves. In 1800, there were 1 billion humans. Today, there are 7 billion of us.

The remarkable thing about this energy surge, however, was that rather than pushing the farming world toward even steeper hierarchies, it did just the opposite. Today, 60 per cent of the world’s population live in democracies, and in almost all of these places women can vote and economic inequality has tumbled. By the 1970s, the average Gini coefficient for income equality (after tax) in the nations belonging to the Organisation for Economic Co-operation and Development was just 0.26. This is close to the levels last seen in the foraging era. Since then, Gini scores have been rising, but even in the 2010s they remain far below the standards of farming societies.

Hierarchies became shallower after 1800. This was because fossil-fuel economies work

by converting an energy bonanza into vast quantities of goods and services, but these vast quantities are no use unless there are consumers able to buy them. Such economies need an affluent middle class, and ideally one that is educated and free to make decisions. Consequently, societies that moved towards free markets, democracy and liberalisation flourished, with the predictable result that people for whom fairness meant treating everyone roughly the same did well.

The lesson of history seems clear. Human

“The struggle to define a perfect set of human values is doomed to failure”

values are biologically evolved adaptations, just like the values of other primates; but the ways we interpret these values are culturally evolved, and this makes us different from all other animals.

If this is true, then several consequences seem to hold. First, moral philosophers’ long-running struggle to define a perfect, one-size-fits-all set of human values is doomed to failure. Aristotle believed that slavery was acceptable because he lived in a farming society where it was necessary. The philosopher John Rawls, best known for his 1971 Theory of Justice, believed that slavery was unjust because he lived in a fossil-fuel society where slavery was not only unnecessary, but also downright harmful.

Second, the values people hold today are bound to change. For 200 years, interpreting justice to mean that steep hierarchies are bad has been a helpful strategy, but energy capture will be different in the future. Maybe the changes in energy capture will reward people who are even more radically egalitarian. This might mean that China and other emerging economies will have to become more liberal if they want to flourish. Or maybe the changes will start rewarding steeper hierarchies. After all, wealth inequality has been growing in most countries since the 1970s.

This kind of inequality, though, might be just the beginning. Within a generation or two, a tiny minority of genetically modified, technologically enhanced post-humans might have outstripped the rest of us as completely, as we modern humans once outstripped the Neanderthals. Human values have come a long way from the simple sense of fairness that Sarah Brosnan found among her capuchin monkeys, but we ain’t seen nothing yet. ■

GROWING FAT TO GET SLIM

IS THERE REALLY SUCH A THING AS FAT THAT CAN MAKE YOU THIN? CHLOE LAMBERT PUTS THE IDEA TO THE TEST

GIVEN my predilection for peanut butter and ice cream, the offer of a scan to measure my body fat wouldn't normally fill me with excitement. But this is no ordinary fat map, and for once I'm hoping to have a lot of the stuff.

While normal white fat stubbornly stores excess calories on hips, bellies and thighs, over the last few years a picture has emerged of a different kind of fat – one which, paradoxically, might help us to lose weight. This is brown fat, which challenges all our assumptions about the fat in our bodies: it burns calories rather than storing them.

It was only six years ago we discovered that brown fat exists and is active in adults. Since then, it has become the focus of

attention as a potential tool to help combat obesity and its related diseases. And the idea that there might be a way to burn through calories without the need to exercise is a tempting prospect for many of us.

"We all know you only need a modest change in energy balance to put on weight – eating one or two extra biscuits a day is enough," says Michael Symonds at the University of Nottingham, UK. "So if you could activate brown fat, or increase its activity, you could potentially reduce your body weight."

Symonds is one of a number of researchers working to develop behavioural, surgical and pharmaceutical therapies that might harness the power of brown fat, and some of these could be as simple as taking a cold dip in the pool or eating spicy food. So when the offer came to work with his team to try and give my own brown fat a boost, I had to give it a try.

What makes brown fat so interesting is its ability to burn food directly to produce heat, whereas energy extracted from food is usually stored first, then released during activity such as exercise. It can produce 300 times more heat per gram than any other tissue in the body. This is because brown fat cells have a disproportionately high number of mitochondria – the small energy producing structures in cells – which also gives the stuff its eponymous colour. These mitochondria are slightly different from those in other cells, too, because they contain a protein called thermogenin, or UCP1, which enables brown fat to turn energy to heat directly.

This furnace-like ability is vital for regulating temperature in some mammals and in babies, who are unable to shiver to keep warm. But until recently it was thought to become

defunct after infancy in humans. Then in 2009, several studies showed that brown fat was present and functional in adults in the neck, shoulders and around the spinal cord.

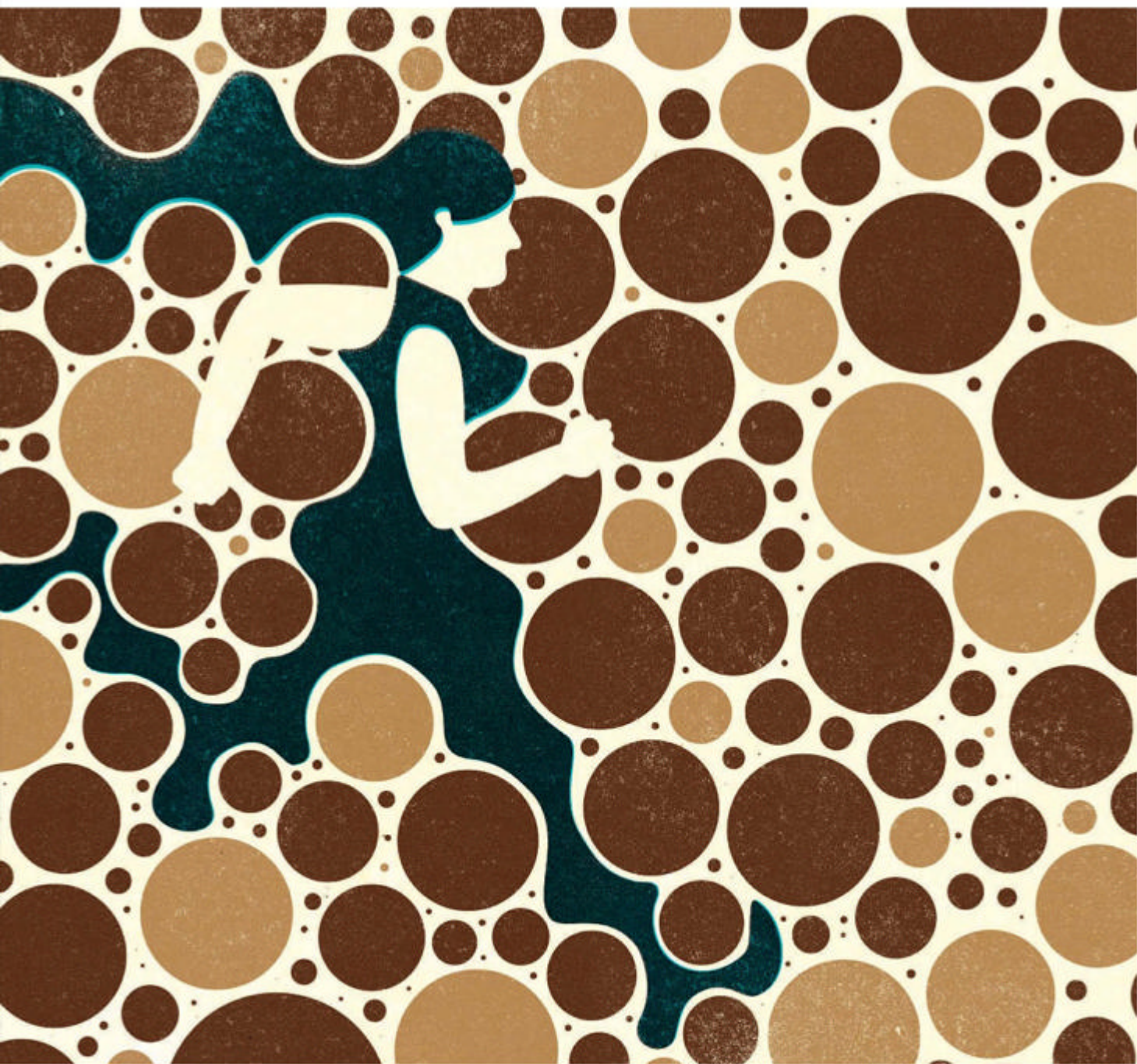
This discovery changed the question from whether adults have brown fat, to whether we can make use of it to help with weight control. "It was a eureka moment," says Symonds.

Although I'm not overweight, the idea of a fat that makes me thinner is certainly tantalising. The amount of brown fat each of us has varies, though. Slimmer people tend to have more of it, which might help explain why some people seem to burn through everything

WHEN GOOD FAT TURNS BAD

Switching on brown fat might help people to slim down (see main story), but switching it off could also be useful. Half of all people with cancer get cachexia, a condition causing extreme thinness, which also accounts for 20 per cent of all deaths from cancer. It now seems that brown fat is involved. Cancerous tumours cause white fat cells to turn into calorie-burning beige fat in mice. If the same is true in people with cachexia, it would explain why they lose weight even if they eat more. Last year, a team at Harvard Medical School identified the protein that tumours release to cause this effect. When mice were treated with an antibody that neutralised the protein, their muscle mass and function were preserved. A similar antibody that works in humans is now being developed, and trials could begin within two years.





ANDRÉ DA LOBA

they eat, while others pile on the pounds.

So the first step is to find out how much, if any, of this “good” fat I have. Because brown fat is activated when the body is exposed to the cold, Symonds and his team have helped pioneer the use of a thermal imaging camera to detect it. The images clearly show two small glowing triangles at the base of my neck – hotspots of brown fat that get brighter when I plunge my hand in a bucket of cold water and the cells set to work (see image, page 34).

Because I have brown fat, Symonds says my best bet to try and burn calories the lazy way is to expose myself to the cold. When

animals are cold, they initially regulate their temperature by shivering. But after repeated exposure, shivering decreases while energy expenditure stays the same. Studies in rodents have shown that this is down to brown fat activity. If the same is true in humans, then regular cold exposure could help you adapt to the cold and burn calories in the process.

Evidence for this comes from an intriguing study conducted by the US army in the 1960s, which subjected 10 almost nude men to temperatures of 11°C, for 8 hours a day for a month. Electrodes on their skin showed that, like rats, shivering decreased after about two

weeks, suggesting that their bodies had somehow adapted to the cold. The team concluded that another metabolic process was at work, although it remained a mystery.

Fifty years later, Anouk van der Lans at Maastricht University in the Netherlands and colleagues wondered whether brown fat was responsible. So in 2012 they recreated the study using PET scans and fat and muscle biopsies to measure brown fat activity, as well as monitoring shivering. After 10 days, brown fat activity had increased and the subjects were better at producing heat without shivering, so they shivered less. ➤

"BROWN FAT CAN PRODUCE 300 TIMES MORE HEAT PER GRAM THAN ANY OTHER TISSUE IN THE BODY"

They also found the cold easier to tolerate.

Encouragingly, in this study, a temperature of about 16 °C was cold enough to switch on the tissue. "Nobody thinks that getting so cold that you're uncomfortable is necessary," says Aaron Cypess of the US National Institute of Diabetes and Digestive and Kidney Diseases, an author of one of the 2009 papers.

But with just five days until my follow-up scan, Symonds says it won't hurt to get temperatures lower than that. So I keep the central heating at home off or on a low setting, even though it's just 4 °C outside. I drink iced water throughout the day, have a cool shower every morning and, for good measure, go for a swim in my local outdoor pool where the water is a breathtaking 3 °C.

How many calories can I expect to shed? Estimates vary hugely. One trial of Japanese men found that spending 2 hours a day in a 17 °C room for six weeks boosted brown fat activity by 50 per cent, and got rid of 5 per cent of their body fat. At the start of the experiment the men burned 108 calories during 2 hours in the cold, but this rose to 289 calories after doing it every day for six weeks.

That doesn't necessarily mean all those calories are burned by the brown fat itself – in studies that only involve short bursts of cold exposure, it could be down to other mechanisms like shivering. For example,

one study of volunteers with an average of 50 grams of brown fat found they burned around 300 extra calories a day when exposed to moderate cold for 30 minutes – but brown fat only accounted for 20 calories of this.

Despite the mixed results, those figures are encouraging enough for some people to make cold exposure part of their daily routine. "The mechanism of how it happens is important to understand, but for practical reasons, the result is what people care about," says Wayne Hayes, a NASA scientist who has created the Cold Shoulder, a waistcoat filled with ice packs designed to activate brown fat.

Cypess and others believe that brown fat could make a contribution to weight loss strategies with regular cold exposure. But what if you don't like the cold? There could be a tastier alternative.

BEIGE IS THE NEW WHITE

Capsaicin, a compound in chillies, seems to stimulate brown fat in a similar way. Mice fed capsaicin as part of a high-fat diet, for example, have increased metabolic activity and don't put on weight. This fits with a small study in which 10 men who took capsaicin pills daily had greater brown fat activity in the cold and burned more calories after six weeks.

"Capsaicin is promising as it is natural, and

relatively safe and inexpensive," says Cypess. "But we are awaiting the definitive experiment showing that a dose of capsaicin directly leads to activation of brown fat."

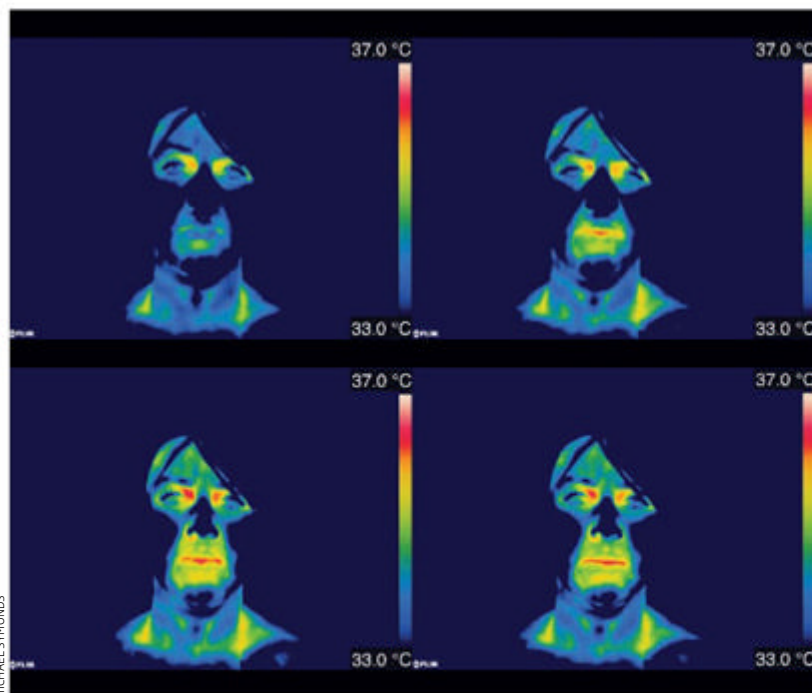
In the meantime, brown fat could have other benefits aside from calorie burning. It releases hormones that help regulate the metabolism of glucose and fatty acids, so might be useful to help treat diabetes and fatty liver disease. Humans and other animals with high brown fat levels have been shown to have better blood sugar and insulin regulation.

But there is a hitch: we have paltry amounts of brown fat and obese people have especially low levels. Stores also deplete as we age.

For that reason, arguably the biggest recent breakthrough in the field has been the identification of a third kind of fat, called beige fat. First described by Bruce Spiegelman at Harvard Medical School in 2012, beige fat has a different origin to classical brown fat, but it contains the same all-important protein, UCP1, which burns calories to generate heat. And while brown fat forms in tight pockets, beige fat is dispersed in white fat cells. Even better, it might be possible to transform white fat into the calorie-burning beige variety (see "Flavours of fat", right).

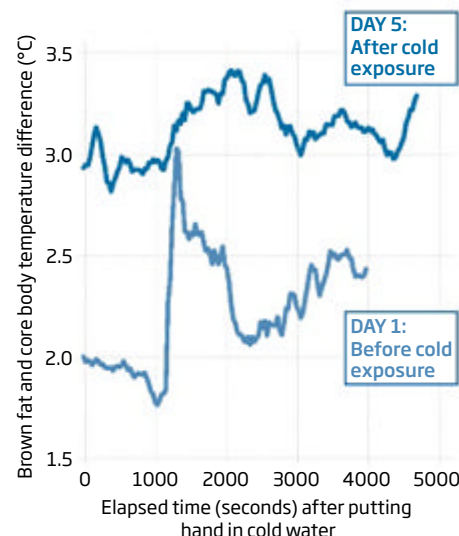
"With most experiments on brown fat you don't induce much new tissue, you just activate it," says Ronald Kahn at the Joslin

Clockwise from top: Brown fat glows brighter as it becomes more active with time after submerging a hand in cold water



Chloe's brown fat boost

After 5 days of cold exposure, Chloe's brown fat was working harder – and burning more calories – as shown by the increase in temperature difference between her brown fat and core body temperature



Diabetes Center in Boston. “With beige fat you get both an increase in the activity, and in the amount. So this is where people believe there are big therapeutic opportunities.”

While most research has so far been in rodents, there is tentative evidence that humans too can turn white fat to beige. One way could be to throw off the duvet. Men who slept in 19 °C bedrooms with only bed sheets had 42 per cent more brown fat after four weeks, found Francesco Celi at Virginia Commonwealth University and colleagues. Glucose uptake increased in white fat, suggesting a rise in beige fat cells nestled within it. The men’s insulin resistance, which is a key issue in diabetes, also improved.

Exercise might also help convert cells. Celi has found hints that a hormone called irisin, produced when muscles contract, stimulates white fat to produce beige fat cells, although the findings are still being debated. For good measure, I keep up my exercise routine, but switch indoor aerobics for a jog in the cold.

When I return to the lab after five days, Symonds’s team finds that the difference between my core body temperature and my brown fat temperature had increased (see graph, left). “That indicates that the brown fat tissue was more active, and having to produce more heat to keep you at a favourable temperature,” Symonds says.

Then came the bad news: the brown fat boost didn’t translate into any weight loss – in fact, I gained a kilogram. Symonds says it may be that brown fat needs to be activated for a longer period to see a change in fat mass. And although I tried to follow my normal diet, he suspects I may have compensated for the cold by eating more. In the sleep study, the boost in brown fat was reversed after the men spent another month sleeping in a warm room, which suggests you’d need to make cold exposure a long-term fixture.

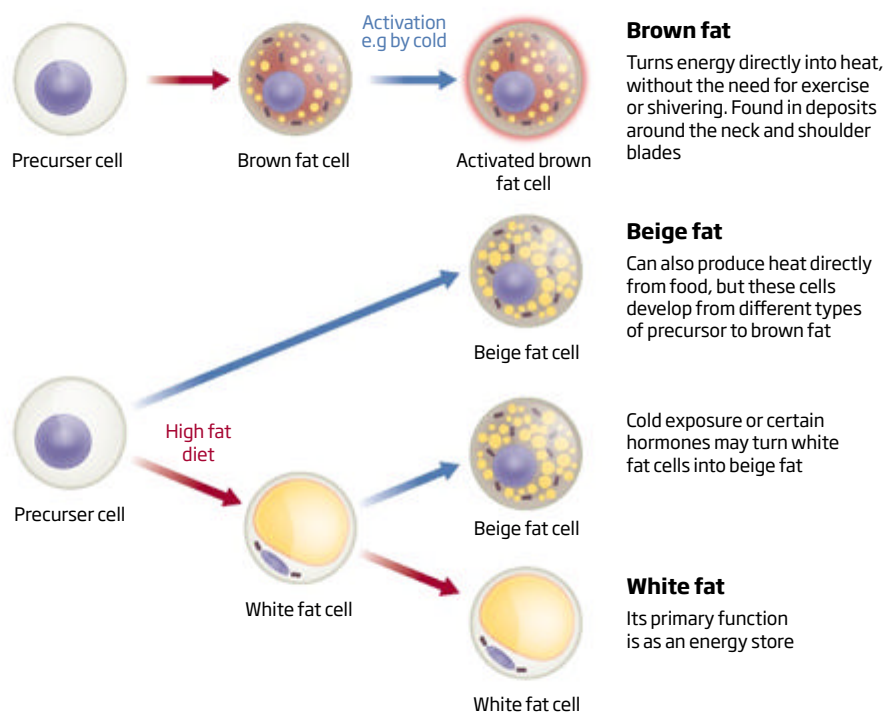
THIRD PILLAR OF WEIGHT LOSS

This highlights a big problem with thinking that boosting brown fat with cold exposure is an easy option: to some people, feeling cold is about as unappealing as slogging it out in the gym or living off salad. And our natural response to cold is often to eat more.

So a better tactic might be to find easier ways to simulate these effects. One hope is mirabegron, a drug developed as a treatment for an overactive bladder that also stimulates receptors on the surface of brown fat cells. In January, a team led by Cypess found an increase in brown fat activity in 12 volunteers after they were given a dose of mirabegron. Their resting metabolic rate increased by

Flavours of fat

Fat isn’t always the enemy when it comes to staying slim. Two types – beige and brown fat – can burn through calories, and animal studies show white fat can turn to beige



203 calories a day. And it works on brown and white fat. “Mirabegron causes white fat stores to break down, likely to be consumed as fuel by brown fat and other organs,” says Cypess.

Another approach might be to convert white fat to brown in the lab and then re-insert it into the body. In 2010, Yu-Hua Tseng at Harvard’s Joslin Diabetes Center took fat precursor cells from muscle and white fat tissue in mice and exposed them to proteins that influence development into brown fat cells. When they then injected them back into the mice, the treated cells developed into brown fat. Tseng’s team has now identified the same mechanism in human fat cells.

A drug that mimics the effects of cold may not be far away either. A team at the University of California has discovered that in cold conditions the body sends signals to immune molecules called macrophages, which trigger browning of white fat to generate heat. Injecting mice with a dose of these signalling molecules activated the same immune response without the need to get cold, and the mice started burning 10 per cent more energy.

Combining such approaches with cold exposure could increase brown fat’s impact. It’s likely that brown fat will become the

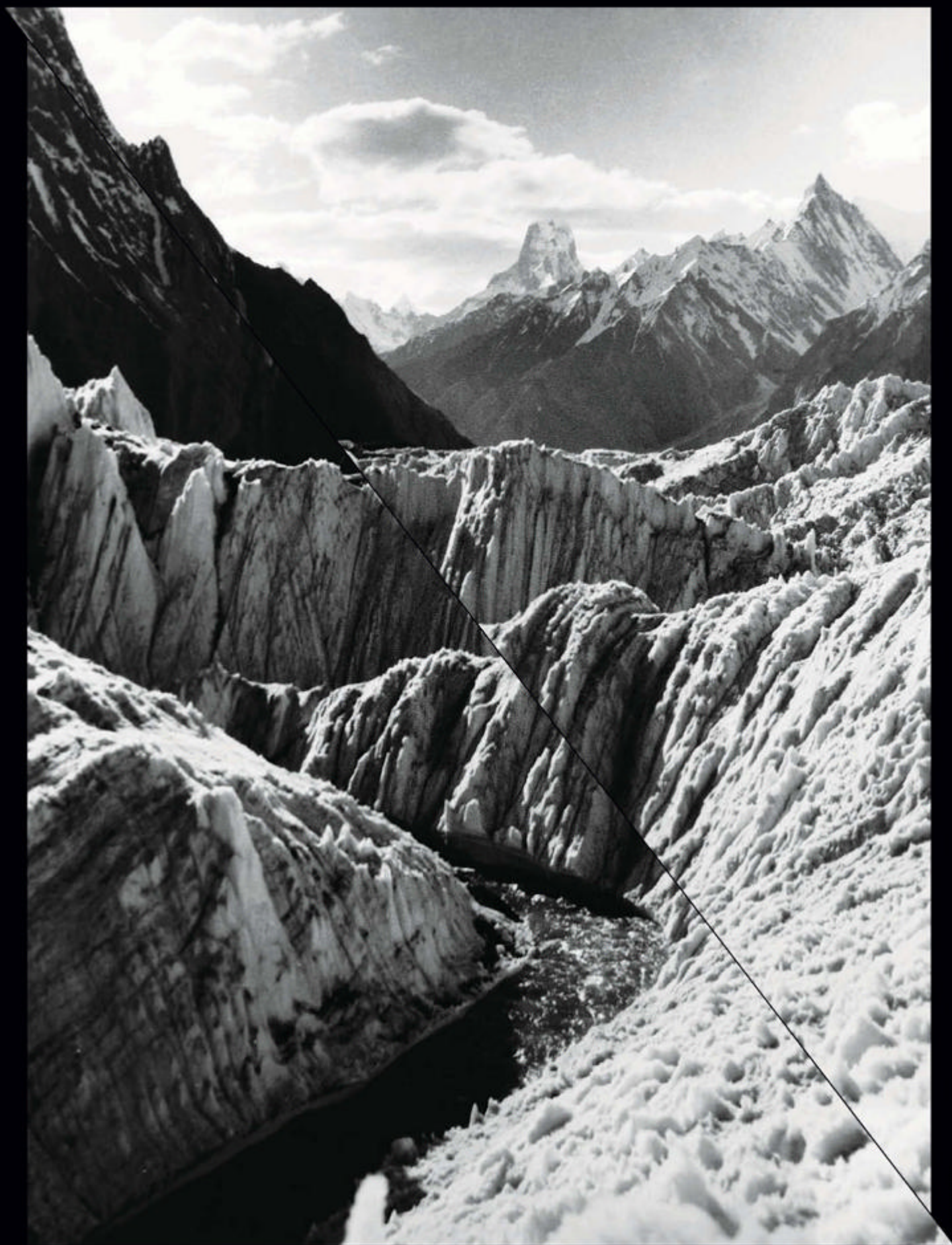
third pillar of weight loss advice, says Cypess. “When you go to your physician, they’ll advise you on eating right, exercising and keeping your brown fat healthy,” he says. “And my hope is that if a person is uninterested in cold exposure they will be able to take a drug.”

Until then, brown fat might not be the magic bullet so many hope. But it could be extremely effective for weight loss if used in combination with reducing calorie intake, says Kahn. Even a conservative estimate of burning an extra 100 calories a day would equate to losing around half a kilogram a month.

And with developments in thermal technology to monitor brown fat, Symonds is optimistic that screening for it could become routine. “It could provide an index of your metabolic health and tell you whether you are at risk of weight gain,” he says.

As for me, the confirmation that I have brown fat, and can manipulate it, has been reassuring and I’ll certainly be turning the thermostat down a few degrees in the winter. All the same, I won’t be rushing back for another ice cold swim. ■

Chloe Lambert is a freelance writer based in London. Links to studies appear in the online version of this article at bit.ly/FatThatBurns





RISE OF THE UPPER CRUST

How did Earth first acquire its continents?
Clues are beginning to surface, says Jeff Hecht

OLIVER JAGOUTZ doesn't have much room for rocks in his narrow tenth-floor office at the Massachusetts Institute of Technology. But the geologist keeps a couple of samples on hand to show visitors how Earth produces something unique in the solar system: continents.

The rocks come from a landscape half a world away, in the remote, hostile mountains of northern Pakistan. But they are a rare record of goings-on deep below Earth's surface. Along with three to four tonnes of other rocks from the region that Jagoutz and his colleagues have gathered over the years, they could hold the key to the enduring mystery of our planet's dry land – and much else besides.

Earth's surface is like no other in our solar system. Sitting atop the partially molten mass of the planet's mantle, like the frothy film on the surface of a simmering pot, are a series of vast slabs of solid rock: the tectonic plates of Earth's crust. That's strange enough, but the crustal plates also contain two rather different ingredients, as Jagoutz's samples show.

The first – a heavy, dark rock called gabbro – is typical of the basalts that line the ocean basins. The second, a granite characteristic of Earth's continents, feels light by comparison.

It's a small but crucial difference. Oceanic crust floats lower on top of the mantle and sinks back into it at subduction zones, where two tectonic plates collide. The oldest oceanic crust is just 200 million years old. The less dense continental crust, meanwhile, bobs higher like an iceberg on water. Plate collisions tend to push it upwards to form mountain ranges, so it can hang around much longer: the oldest known continental rocks are 4 billion years old.

For most of its history, Earth has had just enough water to lay a thin blue skin over the lower, but not the higher, parts of this surface. The relatively stable proportions of sea and land provided an environment unusually suited for complex life as we know it to develop over billions of years. Small wonder the interest in how this situation came about. "The holy grail of geology is to understand the first continental crust," says Jagoutz.

In numbers, the difference between oceanic and continental crust is small. Oceanic crust has a composition similar to that of the mantle, consisting of about 50 per cent silicates. The continental crust is the anomaly, with up to 60 per cent of these lighter minerals.

The continental material makes up a tiny part of Earth's bulk – by mass, it is about 0.5 per cent the size of the mantle – but something, somewhere must have given it this fundamentally different composition. We think we know where this transformation occurs: above oceanic crust that is sinking into the mantle at a subduction zone. Heat and pressure squeeze fluid from the sinking crust, which rises and liquefies mantle rocks above. As this material continues to rise, it begins to separate out into lighter and heavier components. The lighter stuff eventually returns violently to the surface as volcanic magma, where it forms the basis of new continents. As for the heavier stuff, the thought was that it must sink, although where or how, no one could quite tell.

A process like this must have been going on since Earth was very young, and is thought to continue today near largely submarine fault lines where two tectonic plates converge and one subducts. A prominent example is the Izu-Bonin-Mariana ridge, an arc of volcanoes running 2800 kilometres south from Tokyo to the Mariana Islands and Guam, part of the "ring of fire" encircling the Pacific.

Drilling down into such areas could



“Drilling down into the crust, you are happy if you observe just the top 5 kilometres”

MYSTERY OF THE MISSING LEAD

The geological formations of Kohistan have already revealed chunks of heavy rock dropping off Earth's crust and into the mantle (see main story). But the region's unique geography could also answer a perennially thorny question: why Earth's composition doesn't seem to match that of any meteorites. Meteorites are made of the raw material left over from the solar system's construction phase that should also have gone into making our planet.

Taking an average of all known terrestrial rocks gives an unusual ratio of two kinds of lead isotope formed by the decay of radioactive uranium, compared with “primitive” lead that has been around since Earth formed. For decades, geologists have searched for a missing reservoir of rocks with high levels of primitive lead. “It has to be stored somewhere. It hasn't left the Earth,” says Oliver Jagoutz of Massachusetts Institute of Technology.

The falling chunks might be just that missing reservoir. Together with Max Schmidt of the Swiss Federal Institute of Technology in Zurich, Jagoutz examined the rocks from Kohistan and found that the material dropping back into the mantle contains between 6 and 40 times as much primitive lead as previously known upper mantle material brought to the surface through volcanic eruptions (*Earth and Planetary Science Letters*, vol 371, p 177).

With such high levels of primitive lead, these sinking rocks need only make up a small percentage of the mantle to potentially explain the discrepancy. Totting up the balance sheet, terrestrial rocks would then be close to matching the elemental composition of a particular sort of meteorite known as a chondrite.

This could be a decisive piece of evidence in a long-running dispute about Earth's origins. Without having seen such rocks in the mantle directly, it's still far from an open-and-shut case, but Jagoutz is confident. “These are the rocks that were hidden in the mantle,” he says – so heavy that they almost never reach the surface for geologists to find.

provide evidence to test the theory, but that is expensive and difficult, especially in marine environments. What's more, penetration depths are limited. “You can be happy if you observe just the top 5 kilometres,” says Jagoutz.

As an Austrian who grew up in Germany and started researching volcanic arcs in Switzerland, Jagoutz was never particularly keen on life on the high seas anyway. “I don't like ships, so I don't go on them,” he says. “I got seasick, and it was just not worth it.”

Fortunately, Earth's past tectonic convulsions do provide some openings for a landlubber. On occasions, volcanic arcs have collided with continents, and the geometry of the collision has skewed their internal layers, forcing them upwards and spreading them horizontally, to be exposed on the surface following subsequent erosion.

Examples of these prostrated sections are found all along the Pacific coast of North America: in parts of Baja California in Mexico, the core of the Californian Sierra Nevada mountain range and much of Vancouver Island in Canada.

But none of these areas presents a continuous record – rocks from some eras are missing – nor do they extend down to the critical layer for the creation of the continental crust. This lies either side of a line known as the Mohorovičić Discontinuity, or “Moho” for short, which marks the point where the

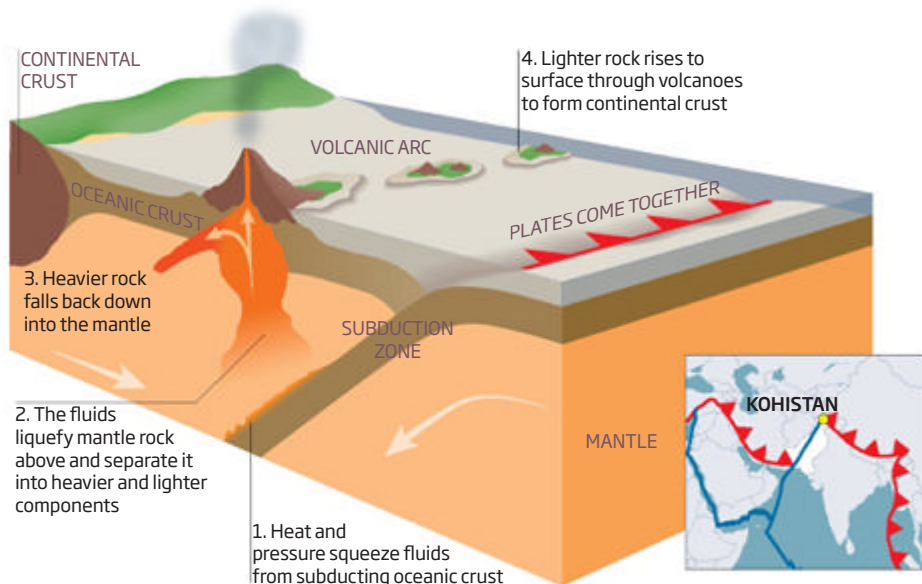
crust meets the mantle. Typically 35 to 40 kilometres under continents and 7 to 10 kilometres beneath the sea floor, the Moho is marked by the change in density – shown in a change of speed in passing seismic waves – between the solid crust and the more mobile, slow-flowing rock below.

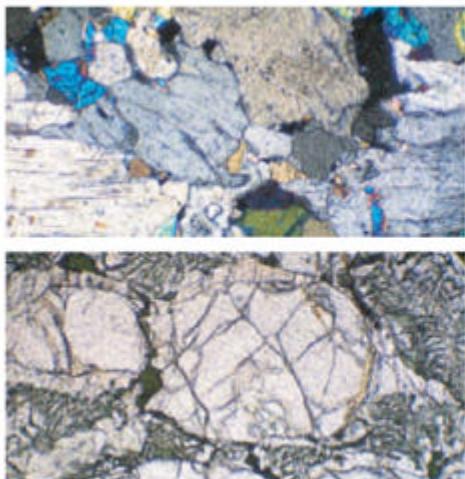
A first tantalising window on the deep opened up in 1989, when geologist Susan DeBari of Western Washington University in Bellingham was studying the Talkeetna volcanic arc, parts of which now lie exposed in south-central Alaska. The properties of some rocks there showed they must have formed at pressures and temperatures corresponding to depths of 30 to 35 kilometres, just at the line of the Moho. There was also evidence of a very dense sort of gabbro, containing as little as 45 per cent silica, that was heavier than the mantle rocks just beneath.

This looked very much like the heavier rock that would be the by-product of making the material of the continental crust. Its position in the exposed arc seemed to imply it would have gone on to sink down into the mantle, under the influence of gravity, had tectonic events not lifted it up and smeared it across the landscape instead. “That dropping-off at the bottom is really the key to creating continental crust,” says DeBari. But it wasn't a clincher: only a few hundred metres of rock below the Moho were exposed, not enough to

Making a crust

In Kohistan, northern Pakistan, rocks that once underlay the boundary between tectonic plates are exposed at the surface. What they show could help to explain how light continental crust comes to exist





The rocks of Kohistan could hold the key to how Earth made its continents

LEFT: JAGOUTZ ET AL. RIGHT: PIERRE BOUILHOL

show what was actually happening at the bottom of the arc.

A decade or so earlier, geologists had identified that formations in Kohistan, in the north-east of Pakistan, and the neighbouring Ladakh province in India were also remnants of an ancient volcanic arc. This had formed some 150 million years ago near the equator, close to a subduction zone in the now-vanished Tethys Ocean between Eurasia and what is now India. Subduction of the edge of the plate carrying India pulled the continent northward until it collided with the volcanic arc about 50 million years ago and began to bulldoze it northward. Then, about 40 million years ago, India collided with Eurasia – with the volcanic arc squashed between.

This great continental train wreck, which also threw up the Himalayas, scooped a huge vertical section of the arc onto the top of the Eurasian continental crust, leaving chunks exposed horizontally in an eye-shaped region some 400 by 200 kilometres. In the millions of years since, continuing pressure crumpled it into mountains, resulting in Kohistan: a geological landscape unique on Earth.

When Jagoutz, then at the Swiss Federal Institute of Technology in Zurich, started investigating the Kohistan deposits in 2000, they “were described in a few different places, but nobody really studied them in great detail”, he says. In the following years, he and a few colleagues went back to the region repeatedly, spending up to three months at a time mapping and studying rock formations, hiring jeeps or donkeys to reach sites and camping in the mountains. At the end of each season, they would haul a tonne or more of rock samples to the airport at Islamabad to ship them back to Europe.

In his office at MIT, Jagoutz opens an old paper map and traces the arc deposits with his finger, showing how the geometry of the continental collision bent the formation and spread it across the surface, and pointing to the thin line marking the suture between the arc and Eurasia. The ability to do fieldwork

over such a large area was essential to get the big picture of the processes going on under the surface. “With square kilometres of outcrops, we can wander around and see what is representative and what is not,” he says.

Sketching out that big picture has taken years of painstaking microscope work, analysing thin slices of the samples to identify their crystalline structure and chemical composition, revealing the depth at which they formed. Each sample was then carefully mapped back to the location where it was found. In this way, Jagoutz determined that the Kohistan rocks formed at a range of depths up to 50 kilometres down. Those further to the north came from shallower depths, while those further to the south originated deeper. “We have the whole sequence of the arc exposed,” he says. “We can walk through the entire crust, essentially just by walking from

“A great continental train wreck scooped a chunk of Earth out onto the surface”

north to south.” The sequence in Kohistan goes all the way down to rocks that crystallised at the Moho – and even a little deeper.

The details proved complex, but it was clear that the Moho, at the time it got scooped to the surface, was shedding rock like nobody’s business. About 70 per cent of molten rock in the zone of transformation was in the process of dropping off back into the mantle, forming a tail of heavy material. Dangling about a dozen kilometres down into the mantle, this stuff consisted of just 45 per cent silica and was enriched in heavy metals such as lead. Further up, lighter, high-silica rock was left to rise – and, had the continents not collided, some of it would eventually have erupted through volcanic openings on to the surface.

A mathematical model showed that chunks must have dropped off the base of the Kohistan arc as regularly as every few hundred

thousand years. “In geological terms, something that happens in a hundred thousand years is momentary,” says Jagoutz. “It rains rocks all the time.”

What makes Jagoutz’s results revolutionary, says Peter Kelemen of the Lamont-Doherty Earth Observatory in Palisades, New York, is that they show how continental crust can be formed in a single step, not the several stages of chemical refinement previously assumed. Rock rising from the mantle mixes with fluid from subducted ocean crust and is distilled as it ascends, forming light continental crust, as well as a heavy slag that sinks back down (see diagram, page 38). “Oli’s result is definitive, really cool,” says Kelemen.

That’s not all. The high lead content of the heavy rock exposed in Kohistan could shed fresh light on Earth’s origin (see “Mystery of the missing lead”, left). Analysis of the rocks of Kohistan is allowing the plate-tectonic forces that spread the volcanic arc across Kohistan to be reconstructed. The results could also explain the tremendous, puzzling force with which India slammed into Eurasia to throw up what is now the world’s highest mountain range. A single subduction zone could only have tugged the two land masses together at a rate of 8 to 10 centimetres a year. India was travelling much faster than this – probably because the volcanic arc squashed in between the landmasses meant not one, but two subduction zones were doing the pulling.

It is already an impressive haul from a few tonnes of rock. The sting in the tail is that there might be a limit to how much we can continue to refine these ideas at present. Jagoutz’s last trip to Kohistan was in 2007, since when unrest has made the region less safe to travel to. The hope is that the samples he has already collected hold enough detail to continue to unpick the mystery of beneath. At least the landlubber Jagoutz can be sure he won’t have to get on a boat. ■

Jeff Hecht is a consultant for *New Scientist* based in Boston



Eye of the beholder

Did the way we see make us what we are?
Veronique Greenwood traces the story of our colour vision



IT TOOK a rather unremarkable garment for people to begin to question their view of reality. On 26 February this year, a photo of a dress went viral – not for its stylishness, but because of its chameleonic colours. Some saw it as blue and black, while others thought it white and gold. Still others, to their enduring unease, saw first one combination, then the other.

The discussions that rippled across the web as a result illustrated a fundamental truth: colour is one of the most vivid and personal experiences we have. But while colour feels extremely real and present, we are still learning exactly how events in our evolutionary past combined to create our particular form of colour vision – and beyond the odd optical illusion, just how important it has been in making us who we are. “Humans wouldn’t be here if we didn’t have colour vision,” says Jay Neitz of the University of Washington in Seattle.

The first thing about colour is that it doesn’t exist beyond the beholder. We can’t be sure a goldfinch will appear the same sprightly yellow to anyone or anything that sees it. What does exist, though, is its tendency to absorb almost all the light that shines on it, and to reflect the remainder back into the world.

That reflected light pours into your eye, illuminating its retina – a wall of cells that,

under magnification, looks like it is covered by a shag carpet. Some of the strands are cone cells, housing light-sensitive proteins called cone opsins; others are rod cells, which allow us to see in low light.

Seeing in ultraviolet

Most people have three cone opsins, each most sensitive to a different wavelength of light: labelled short, medium and long wavelength or simply blue, green and red. The brain’s visual system compares the messages from all three to assess the wavelength mix striking the eye. The result is something like a three-note chord – a harmony that your brain assembles, with each colour having its own particular qualities. Subtle differences in tonality allow us to distinguish something like a million of these chords, each representing a different shade of colour.

The first opsins appeared more than 600 million years ago, and creatures as different as humans and jellyfish possess them. In the first instance they acted as a basic light sensor. But as more intricate visual systems emerged – such as the eye, which first appears in fossils from around 520 million years ago – so opsins, too, have evolved. Creatures have tweaked the versions they inherited, duplicated them, lost them and shifted their sensitivity from one

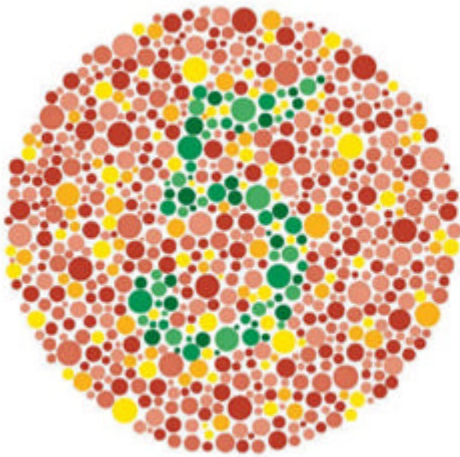
wavelength range to another. Humans may have three opsins, but goldfish have four, dogs two and mantis shrimp 12. The relationship between the opsins of mice and us, say, is not clear-cut. “It’s not a given that ours derived from theirs, or what our last common ancestor had,” says Edward Pugh, a molecular biologist at the University of California, Davis.

It does seem that the common ancestor of mammals and fish had four opsins – as many fish, reptiles and birds descended from that common ancestor still do today. These include one that responds to ultraviolet light, meaning they can perceive light that is invisible to us. Since that common ancestor, though, the story of opsin evolution in mammals has been “a history of loss”, says Almut Kelber, a vision researcher at Lund University in Sweden.

For a start, some time in the early evolution of mammals half of the opsins fell by the wayside – perhaps because our ancestors became nocturnal and relied more on the use of low-light rods than colour-responsive cones. Then one of the two remaining opsins, possibly the ultraviolet one, underwent a transformation: in effect, it became our blue opsin (see diagram, page 43).

Biologist Shozo Yokoyama at Emory University in Atlanta, Georgia, has recently suggested that the only way this could have happened was if the seven necessary alterations in the protein code came in a precise sequence. Why did those changes stick? No one knows for certain, though it could be that a shift to a blue opsin reduced blurriness and improved resolution, says John Mollon, a neurobiologist who studies colour vision at the University of Cambridge. The move may also have freed our ancestors to cut down the amount of damaging ultraviolet penetrating the eye during daytime activities without compromising their vision, says Jerry Jacobs of the University of California, Santa Barbara. Whatever the reason, the modified opsin proved useful – so useful that it remains with us today.

One consequence of this evolution is that our blue opsin is still sensitive to some ultraviolet light. Normally, the cornea and lenses of our eyes absorb this light before it reaches the retina. But sometimes when people being treated for cataracts have their natural lenses removed, they begin to see ➤



Eyeballs with secrets

Colour blindness is a condition that mainly affects men. Three-quarters of colour-blind men have the standard three types of retinal colour receptor proteins, known as opsins, one of which is faulty. But about a quarter have lost an opsin altogether, because the gene that codes for it has been lost.

One of the earliest descriptions we have of colour blindness turns out to be a case of a missing opsin. In a 1794 lecture in Manchester, UK, celebrated 18th-century chemist John Dalton noted, "I have often seriously asked a person whether a flower was blue or pink, but was generally considered to be in jest."

Dalton thought the fluid in his eyes might be tinted, but when (according to Dalton's wishes) his doctor sliced open his eyeballs after his death, the fluid was clear. The doctor was unable to solve the mystery, but the eyeballs were preserved, and in the 1990s, neuroscientist John Mollon at the University of Cambridge and his team took samples for DNA testing. Dalton, they discovered, had no gene for the green opsin.

They bolstered their DNA evidence by comparing the optical qualities of 18th-century red sealing wax with deep green laurel leaves, which Dalton wrote were exactly the same colour to him. They found that, for someone who is missing the green opsin, the light reflected off those items should make them appear very similar. (*Science*, vol 267, p 984).

HIDING IN PLAIN SIGHT

The Ishihara test for colour blindness, published in 1917, is still commonly used today. Named after its creator, the Japanese ophthalmologist Shinobu Ishihara, the test employs a series of round images made up of dots. Each image contains numbers and patterns that are only identifiable by hue. In the test on the left, people with normal colour vision should be able to pick out the number five, while people with red-green colour deficiency – who have difficulty distinguishing between green and red – cannot. In the test on the right, people with red-green colour deficiency perceive the digit two, while people with normal vision see no number.

ALAMY

patterns on flowers and violet tinges appear on objects that used to look black. The French impressionist painter Claude Monet, for instance, had cataract surgery on his left eye at the age of 82, and some have speculated that it accounts for the blue and violet hues of his final paintings.

For dogs, cats, horses and hyenas, the story of vision ends there with two opsins. Even many new-world monkeys, our cousins in the primate family, only have two. Of the mammals, only some old-world monkeys and the great apes – humans included – developed trichromacy, the three-colour system we retain today. That happened between 30 and 45 million years ago, when first the gene for the red opsin duplicated and then mutations shifted the sensitivity of the duplicate into the green wavelengths. With it, we went from being able to distinguish some 10,000 shades to a million.

Why did this new form of colour vision take over? One long-standing theory is that being able to distinguish calorie-rich, reddish fruit from the surrounding green foliage, as this adaptation allowed, would have given our ancestors a distinct advantage. "I still think it's a very plausible hypothesis," says Mollon. "Sometimes, tongue in cheek, I have said that humans and the whole primate lineage are an invention of trees for propagating themselves."

Mutants among us

Mollon thinks that this might have been about more than just fruit. Tender young leaves, other primates and their markings, certain types of predatory snake – "all these would be visible against a variegated background once you could compare the signals from long- and middle-wave pigments", he says. Neitz goes further. He suggests that by allowing us to ingest more calories, this development allowed us to grow bigger brains, starting a positive spiral that allowed us to use colour vision in ever more sophisticated ways.

Ultimately, it's the complexity of the way that such big brains construct colour that helps to create illusions such as that of the dress (see "The mystery of 'The Dress'", page 43). Regardless of trichromacy's role in that development, it has created other fascinating quirks of human colour vision. The red and green opsin genes reside on the X chromosome, of which women have two and men only one. About 6 in 100 men have mutations in one of these genes that make the red and green opsins very similar. A woman with this mutation has another X chromosome that usually provides a normal opsin, but a man has no back-up, making it more difficult for him to tell reds from greens. He is colour-blind.

We have known about colour blindness since at least the 18th century (see "Eyeballs with secrets", left). But with two X chromosomes, women with a mutated red or green opsin can end up with four types of opsin. That means that they might, if their brains can make sense of it, create chords with four notes, enabling them to distinguish some 100 million colours.

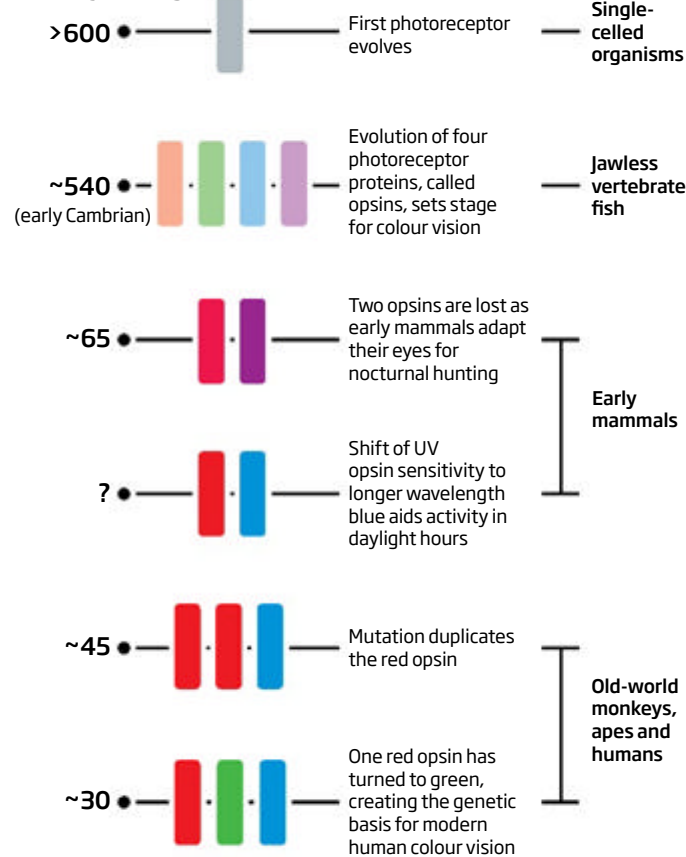
The Dutch scientist Hessel de Vries was the first to make passing reference to this, when he recorded in 1948 that daughters of colour-blind men responded differently to colour vision tests than other people. (Men, of course, get their X chromosomes from their mothers and pass them on to their daughters.)

Decades later, Mollon came across de Vries's paper. Together with neuroscientist Gabriele Jordan, now at the University of Newcastle, UK, he began to test women with four different opsins. In 2010, the team revealed that they had found one woman, a doctor in Newcastle, who could distinguish shades

Colour scheme

Our ancestors tried out a lot of variants on colour vision before our branch of the primate tree developed the three-colour version we use today

Million years ago



The mystery of "The Dress"

If you found yourself bamboozled by the picture of the blue and black (or was it white and gold?) dress that took the internet by storm earlier this year, you can comfort yourself that at least part of the story is that your brain is so very complex.

The white-gold effect comes about because the brain attributes the brightness of the image to the garment (which, as is clear from the picture above, was sold as blue-black), rather than to the light pouring onto it. This unconscious ability to compensate for an object's surroundings and the quality of the light is ancient – certainly older than primates – but there's more to it than that.

Expectation, for instance, plays a role in what we perceive. Some people may have thought the dress was a wedding dress, helping to tip the balance towards white; others may have read that it was blue, pushing things the other way. Jay Neitz of the University of Washington in Seattle sees it as white, but is nevertheless also aware of the blueness coming from the image. For him, the variation in perception illustrates the rare subtlety of the interplay between our eyes and our brains. "I think that that's a primate thing. That's a big brain thing," he says.

mixed by a computer that appear identical to everyone else. She is the first of her kind known to science (*Journal of Vision*, DOI: 10.1167/10.8.12). Why her, and not other women with four opsins? "That's a tough one," says Margaret Livingstone, who studies how the brain processes colour at Harvard Medical School. It might be that some extra change needs to happen in the neural circuitry to make sense of that extra information, or that the extra opsin gene is not expressed in the retinas of everyone who has it.

And it's not always quite as simple as more opsins, more colours, as evidence gathered from mantis shrimp, with their 12 types of opsin, suggests. Last year, a team led by Justin Marshall at the University of Queensland in Brisbane, Australia, showed that mantis shrimp trained to respond to

colours using food rewards stopped being able to distinguish between colours much earlier than humans (*Science*, vol 343, p 411).

The explanation for their large number of opsins might lie in their neural processing power. "It might just be an adaptation for not having a big enough brain to be able to do real comparisons of colours," says Michael Bok at Lund University. Our back-end processing lets us perceive colour as a symphonic experience that can convey meaning and beauty. But for the mantis shrimp, it may be a behavioural trigger: the colour pattern of a predator means time to zip away; that of a potential mate indicates it's time to stick around.

It's natural that we should be curious about what creatures with more opsins see. But it seems our meagre three, coupled with our enormous brains, haven't done so badly for us. It may have taken a dress to alert us to the intricacies of our own colour vision – but certainly, somewhere along the line, it has become about a lot more than spotting fruit. ■

Veronique Greenwood is a freelance writer based in Boston

"It might just be an adaptation for not having a big enough brain"

JOE GIDDENS/PA

Design out of disaster

Can sustainably minded designers help fix the future, wonders **Simon Ings**

Designs of the Year 2015,
Design Museum, London

IN FRIENDLY competition with Percy Bysshe Shelley, the poet Horace Smith once wrote a poem entitled *Ozymandias*. Shelley's version is the one we remember, but Smith's is compelling for another reason. He imagines a hunter traipsing through the ruins of a future London. Lighting upon a fragment of a monument, he "stops to guess/What powerful but unrecorded race/Once dwelt in that annihilated place".

This year's Designs of the Year competition has its monumental moments, but even the most grandiloquent of the 76 entries at least tips its hat to the idea that Earth will not sustain another great ruin, or may even end up as our next great ruin, unless we respond more cleverly to our environment.

Jean Nouvel's One Central Park in Sydney, Australia, towers above its competitors, literally. Clad in climbing plants by Patrick Blanc, the leading designer of vertical gardens, the building's overriding purpose seems to be as an apology for its very existence. There is even a motorised heliostat mounted on a cantilever near the roof, to erase its shadow. The arrangement looks terrifying in photographs, suggesting the 50-metre-high moontowers of 19th-century experiments with civic lighting.

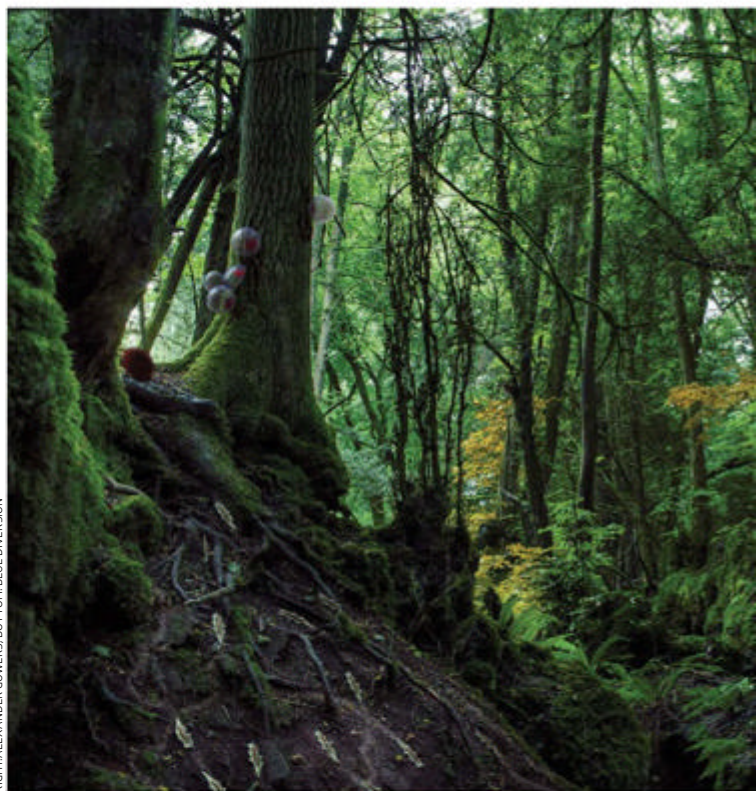
In Vietnam's Ho Chi Minh City, a project called House for Trees eschews apology for action, albeit

eccentrically. Here, high-density living units double as gigantic containers for tropical trees. Come the rains, a sufficient number of these properties could reduce the risk of urban flooding. At least, so claim architects Vo Trong Nghia, although it sounds like special pleading to me – an alibi for the strange green dream they are weaving, of wandering lost among giant plant pots.

Where rains are few, a more down-to-earth aesthetic holds sway. PITCHAfrica's Waterbank Campus is a 10-acre school site in Laikipia, Kenya, where 4 acres of irrigated conservation agriculture are fed by seven low-cost buildings, designed to collect and store what little precipitation there is.

PITCHAfrica's vision extends beyond unassuming architecture to providing resources like clean water, food and sanitation on-site for its students, in the hope they will spread the word about how to manage scarce resources at home.

This vision of a built "ecosystem capable of empowering and



RIGHT: ALEXANDER GOWERS; BOTTOM: BLUE DIVERSION

Into the woods: in an imaginary future, synthetic bugs repair soil

transforming communities" is shared by a great many of the show's "technical fix" entries. Take the Blue Diversion toilet. This project, led by the Swiss Federal Institute of Aquatic Science and Technology, and funded by the Bill & Melinda Gates Foundation, is an all-in-one sanitation, fertiliser, drinking-water and biogas solution. In this cheap, ugly, blue plastic toilet, nothing is wasted – not even sunlight: there is a small solar panel on its roof.

Other ideas plug in to attempts to improve city life. Take Peru's University of Engineering and Technology in Lima, where researchers have invented a billboard that purifies the air in a five-block radius, scrubbing it clean of construction dust and 99 per cent of airborne bacteria – normally the work of 1200 trees, says the team.

Another entry, The Ocean Cleanup, designed by Erwin Zwart

with Boyan Slat and Jan de Sonnevile, tackles the plastic garbage in the world's oceans. Why not string barriers over the waves to catch the plastic as it circulates? Having raised over \$2 million through crowdfunding, the organisation is planning large-scale pilots.

This is technical fixery at its purest. It doesn't prevent the oceans being littered: it is an environmental sticking plaster,

"It is simpler for designers to ameliorate or disguise problems, rather than address them head on"

permitting us to pursue business as usual. But why should designers carry the whole world on their shoulders? Designs like these could be part of a broader, political solution. The Ocean Cleanup's barriers would be a fitting monument for our descendants to puzzle over.

Better to avoid collapse entirely, but it won't be easy.



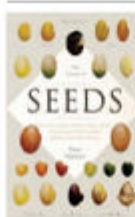
Blue Diversion toilet: a throne of sustainability, nothing is wasted



Seeding the future

We owe a lot to the invincibility of seeds, finds **Adrian Barnett**

The Triumph of Seeds: How grains, nuts, kernels, pulses, and pips conquered the plant kingdom and shaped human history by Thor Hansen, Basic Books, \$26.99



“THAT spark of dormant life may be hidden and hard to measure, but mother plants will do almost anything to protect it,”

writes conservation biologist Thor Hansen, describing the marvels that are seeds.

Ranging from the human-head-sized coconut to the dust-fine contents of the vanilla orchid pod, we see how seeds are far more than lumps of plant tissue, waiting around for watering before they spring into action. They are a plant’s babies, lifeboats of genetic succession cast off into the sea of an uncertain future.

Without the act and anticipation of planting seeds and harvesting them, Hansen insists, there could be no agriculture as we know it. Instead, our species would still be wandering in small bands of hunters, gatherers and herdsman. Without seeds, human history might have been very different.

The triumph of the book’s title is attributable to seeds being both well provisioned with rations and replete with cunning devices to repel boarders and ensure success once a germination-friendly spot is reached. Seeds are finely crafted survival machines, designed to withstand whatever chance, change or the teeth and intestines of animals might bring.

Hansen’s book is packed with facts, figures and colour: seed

plants make up more than 90 per cent of the world’s flora; in Egypt, the word *aish* means both bread and life; the shape of the stealth bomber aircraft was inspired by the flying-wing design of Javan cucumber seeds. The pages burst with enthusiasm and observation, as the author explores the role of seeds in human evolution and the rise of civilisations, tracking back to an antiquity that began with *Homo erectus*.

We travel from deep-frozen gene banks, via academics studying how seeds survive centuries of desiccation, to the vibrant natural world. Here, Hansen explores the origins of seed evolution, and the variety of colours, shapes, sizes and survival strategies they possess.

In the modern world, with more than half of us living in cities, we take seeds for granted. Yet if you had coffee or bread today, thank a seed. If you cook with a vegetable oil, you are using the energy store of an ungerminated baby plant. The annual output of the bean

(a seed, of course) provides protein for more of the world’s population than all cows, chicken and fish combined. And while one seed-making species, wheat, covers more of Earth than any other crop, the globe’s 32,000 seed-producing species are its dominant botanical force.

With light, engaging prose Hansen shows how the little spheroids we tip out of a packet

“Seeds are a plant’s babies, lifeboats of genetic succession cast off into the sea of an uncertain future”

are in fact supremely elegant genetic time capsules. *The Triumph of Seeds* takes you past the casing into the extraordinary inner working of objects without which our landscapes, dinner plates and gardens would be unrecognisable. You will never be able to look at an orange pip or a sunflower seed in the same way again. ■

Adrian Barnett is a rainforest ecologist at Brazil’s National Institute of Amazonian Research in Manaus



FREDERIQUE JOUVAU/PICTURETANK

It is simpler for designers to ameliorate or disguise problems, rather than address them head on. It is next to impossible to imagine how we get from a wasteful here to a sustainable there. This is why, for me, Alexandra Daisy Ginsberg’s *Designing for the Sixth Extinction* is the exhibition’s posterchild. In her design fiction, Ginsberg has anatomised the ultimate disruptive enterprise, in which “nature is totally industrialized for the benefit of society”.

Although her synthetic creatures are deliciously creepy (especially the “biologically-powered mobile soil bioremediation device”), it is her business model of saving our civilisation at the expense of the natural world while replacing it with something better that is fascinating. If Ginsberg’s vision comes to pass, our descendants won’t puzzle at our monuments. Our monuments will be everywhere, all around them and inside them. ■



FRAZER HUDSON/KONIMAGES

Knocking cancer out

Fighting cancer takes creativity – and a whole lot of persistence.

Katharine Gammon investigates the jobs that are helping to tackle the disease or prevent it from happening in the first place

THE best weapon against cancer is prevention. Once it takes hold, the onslaught can be difficult to stop. Fortunately, researchers are coming up with creative ways to avoid, slow and treat cancer's march in the body.

There are signs that the fight is building strength. In the past, it took decades for treatments to be tested and approved. This year, several cancer immunotherapy drugs have shot to market after just a few years of development. Between 2010 and 2014, the Food and Drug Administration approved 37 cancer drugs, compared with just 19 between 2005 and 2009.

"We're starting to scrape the surface of new cancer therapies," says Kevin Gergich, a clinical development scientist at pharmaceutical company Merck in Rahway, New Jersey. "There's so much that we don't know, but we are pushing the field forward." New treatments and prevention are making lives easier for millions – but there is still a long way to go.

Currently, determining the best treatment for a patient at the correct time is a guessing game, dependent on a host of factors such as whether the cancer might grow or spread. One exciting attempt to solve the problem echoes the mapping seen on television weather reports that can predict a hurricane's path. The hope is that

the same sort of intricate math-based prediction could also usher in smarter cancer treatments.

Paul Macklin's work is using out-of-the-box thinking to create a standardized modeling system for math-based cancer models. Such models would vastly improve doctors' ability to predict what cancer will do in an individual patient. They would also help speed up the drug development pipeline, by testing potential

"Clinical research opened the door to help people through cutting-edge treatments"

drugs on millions of simulations with digital cell lines long before they reach patients.

Macklin is a mathematician and assistant professor at the Center for Applied Molecular Medicine at the University of Southern California in Los Angeles, and his lab is working on powerful three-dimensional computer models to simulate how millions of individual cells interact in development, cancer, and

treatment. He actually began his career looking at crystal growth and aquifer models, and says an indirect route into cancer research is becoming more common as different approaches and methodologies open careers in cancer science to a wider range of backgrounds. “The language of math means I can do a lot of things that are interesting, and I’ve always been interested in cancer,” he says. A few decades ago, however, “those jobs just didn’t exist.”

Macklin doesn’t stay cloistered in the world of numbers, however. While doing a master’s degree in industrial and applied mathematics at the University of Minnesota–Twin Cities, his research mentor encouraged him to look at math’s applications within cancer research.

After completing his doctorate at the University of California–Irvine, he sought to work with clinicians on patient data, and decided on a research position at the University of Texas Health Science Center in Houston. Often he’d hurry across the campus from his computing group to meet with the biologists he was working with. “It was there that I started to work on slides with pathologists – they’d show me an endothelial cell, a cancer cell and a normal cell,” he says. “Being one-on-one with them was the best training I could get.”

Better than a cure

Preventing people getting cancer at all is the aim of Olivera Finn, professor and chair of the Department of Immunology at the University of Pittsburgh School of Medicine in Pennsylvania. She works on an antigen – a substance that the immune system needs to identify potential biological threats – called MUC1. The antigen is present in 80 percent of human tumors, including cancers of the breast, colon, pancreas and lung. Finn found that many tumors have an abnormal form of MUC1 that could be recognized by the immune system as foreign. Several trials using tumor-associated antigens are ongoing, and researchers looking at MUC1 are hoping to formulate a vaccine that could create a long-term ‘memory’ of the cancer antigen in the immune system, so that the body could squash cancer if it ever appeared.

Cancer vaccines are being tested on people with pre-malignant lesions (the cell state associated with an increased risk of cancer), but Finn says that in the future, they could be given to healthy adults. “As scientists, it is our duty to develop these things,” she says.

Coaxing the body’s own immune system into attacking cancer is the idea behind a wave of new drugs. Gergich planned to become a doctor but switched to study biology in graduate school,

CASE STUDY A CAREER AT THE COALFACE

WHEN Cigall Kadoch was in high school and eager to delve into a world of science, she had the opportunity to take on an unusual internship at Harvard and work face-to-face with patients as she followed oncologists on their rounds. The experience has never left her.

“That was my first appreciation of the fact that our current knowledge and toolbox of therapies cannot cure most cancer patients,” says Kadoch. “Underlying every patient was a unique biologic puzzle that hadn’t been solved.”

Now a researcher at Dana-Farber/Boston Children’s Cancer and Blood Disorders Center and Harvard Medical School, Massachusetts, Kadoch studied molecular and cell biology at the University of California Berkeley. After graduating in 2007, she went into doctoral

studies at Stanford University Medical School, also in California, where she began to study chromatin regulation in human cancer.

Chromatin is the stuff that keeps 1.8 meters of a cell’s DNA spiraled up like a phone cord in the five microns of space available in the nucleus, and Kadoch was the first author of two papers published in 2013 that showed that mutations in the protein complex involved in unraveling DNA and selecting the right part to replicate were implicated in up to a fifth of all human cancers.

Her papers helped Kadoch head straight for assistant professor jobs rather than work as a postdoctoral researcher. She now runs a lab of 16 members at Harvard and the Broad Institute in Cambridge, Massachusetts. By focusing on a specific type of



rare, pediatric tumor, Kadoch says she can start to reveal how this protein complex works – or doesn’t – and open up opportunities to avoid the mutation in the first place.

“There’s a tendency for young professors to jump to every possible thing,” she says. She explains there is a danger in leaping to any possible new line of research without following through, and that it’s best to find something that can keep you focused.

Kadoch gets hers by “walking up to the lab each morning through the Pediatric Oncology clinic and seeing these sick kids,” she says. “There is no better motivation or reminder of the importance of the work we are doing.”

and a conversation with his grandfather spurred him to look into scientific research.

“He told me how medicine was changing and how I could make a difference in another way,” he says. “Clinical research opened up the door to still help people, but in a different fashion: it was about cutting-edge, new treatments.”

Stronger together

Merck’s Keytruda drug fights melanoma by turning off a chemical signal that hides cancer, enabling the immune system to recognize it and fight it. Treatments such as this are valuable pieces of an oncologist’s toolkit, but they could be even more powerful by pairing them with other drugs, says Gergich. Such drug combinations are effectively limitless and will require investigation themselves, creating new research roles.

“If you look at how cancer therapies are generally run, the cornerstones rely on a combination of new drugs,” he says. “The potential is tremendous.”

For Sameek Roychowdhury, working in cancer research is all about being part of a larger team. Roychowdhury is a physician-scientist in

medical oncology at the Comprehensive Cancer Center at the Ohio State University in Columbus, where he focuses on cancer genomics and implementing precision cancer medicine. In an average day, he spends 90 percent of his time on clinical research and 10 percent seeing patients with advanced cancer.

Roychowdhury says his job uses a ton of multidisciplinary skills. “Medical oncologists use approaches like sequencing, but also molecular pathology, computational biology and genetic counseling, he says. “We try to merge those to solve some real human problems.”

He says the concept of team science – that people with different specializations can do more together than alone – is catching fire in the world of cancer. “I like to use a sports analogy for science, and one path to success is through working as a team,” he says.

Roychowdhury likens himself to a coach on a training field. “You could put a whistle around my neck,” he says. “I’m always telling my students to be passionate about what they’re doing.” ■

Katharine Gammon is a writer from Santa Monica, California



Post-doctoral Fellowship on Mouse Models of Cancer

Washington University School of Medicine is one of the top five US medical schools and is a leader in cancer genome sequencing. By mining breast cancer genomics data, the laboratory of Dr. Ron Bose identified activating mutations in the HER2 Receptor Tyrosine Kinase (see Cancer Discovery, 3:224-37, Feb. 2013). Transgenic mice and Patient-derived Xenograft models allow us to test the role of HER2 activating mutations in several solid tumors, to study interaction with other oncogenes, and to determine drug sensitivity.

We are looking for an experienced animal researcher who can lead this effort. Requirements:

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rbose@dom.wustl.edu.

For further information: http://oncology.wustl.edu/people/faculty/Bose/Bose_Bio.html and <http://dbbs.wustl.edu/>

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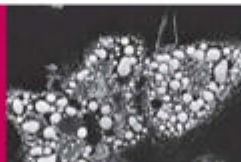
Minimum Qualifications: BS in Biological Sciences or other relevant field; hands-on experience in research laboratory environment; experience informing superiors and peers based on their information needs; committed to exceeding quality standards and providing exceptional services; exhibits meticulous attention to detail; committed to producing accurate and high-quality work; practiced documentation skills; uses multiple resources, quantitative, and qualitative research methodologies to capture and interpret information; aware of basic safety issues; follows safety procedures and maintains a safe work environment; trained in hands-on equipment maintenance.

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GYNECOLOGICAL CANCER RESEARCH POSITION

Department of Pathology

The Department of Pathology at the University of Alabama at Birmingham (UAB), in collaboration with the UAB Comprehensive Cancer Center, is committed to building an active research program in the area of gynecological cancer. We are therefore inviting applications for a tenured or tenure-track faculty position at the Associate or Full Professor level from scientists (Ph.D., M.D., M.D./Ph.D.) depending on experience, research and scholarly accomplishments. Applicants should have an actively funded research program in the area of gynecological malignancies. Successful candidates will have a demonstrated record of originality and productivity in research with existing NIH funding as well as a commitment to graduate education in cancer biology. Exceptional candidates will be eligible for appointment to the Hazel Gore, M.D., Endowed Professorship in Gynecologic Pathology. UAB, which ranks in the top 25 in NIH funding, is a dynamic, collaborative research institution with state-of-the-art facilities, excellent graduate programs, and a commitment to post-doctoral education. Faculty will be expected to participate in the training of graduate students. The candidate will be appointed as a member of the Division of Molecular and Cellular Pathology in the Department of Pathology. A pre-employment background investigation is performed on candidates selected for employment. Interested candidates should submit a cover letter that includes research interest/experience, a curriculum vitae, and the names of three references to: Ralph Sanderson, Ph.D., Chair of Search Committee, Professor, Division of Molecular and Cellular Pathology, Department of Pathology, email PATH-MCPFRecruit@mail.ad.uab.edu

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For more information visit www.wakehealth.edu or contact mkiger@wakehealth.edu

Annual Biomedical Research Conference for Minority Students (ABRCMS)

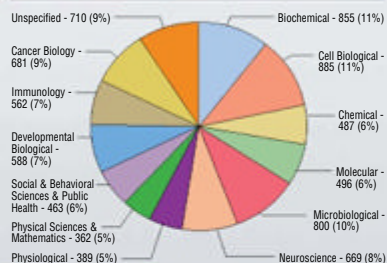
Washington State Convention Center • Seattle, WA • November 11-14, 2015



ABRCMS advances undergraduates and postbaccalaureates from underrepresented populations, including those with disabilities, in science, technology, engineering and mathematics (STEM) along the path toward graduate-level training. The conference features 1,700 poster and oral presentations, scientific sessions, professional development and networking sessions, and approximately 325 exhibit booths showcasing summer research and graduate school opportunities.

"Attending and winning in my category was one of the best experiences in my scientific life. Coming from my background, I doubted myself in the past. I now feel confident because when I presented my poster I left like I belonged. This conference really made me believe that I can pursue a career in science." STUDENT

2014 Distribution of Scientific Disciplines



Important Deadlines

Abstract Submission: September 11, 2015

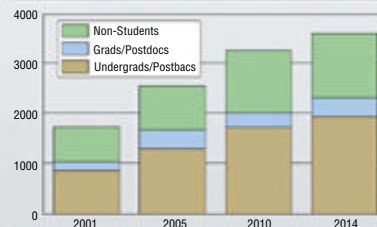
Travel Award Application: September 11, 2015

Judges' Travel Subsidy Application: September 25, 2015

Discount Registration: October 19, 2015

For more information, please visit: www.abrcms.org.

ABRCMS Registration



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The University of Alabama at Birmingham

DIRECTOR, DIVISION OF INFORMATICS Department of Pathology

The University of Alabama at Birmingham (UAB) Department of Pathology is seeking an outstanding candidate at the **tenure/tenure-earning Associate Professor or Full Professor** level with experience in the field of biomedical informatics to lead its Division of Informatics. Extensive experience in biomedical informatics, or bioinformatics/computational biology and a **M.D. or a Ph.D.** in a related professional field is required. Candidates must have a demonstrated expertise in one of the areas of biomedical informatics and the ability to retain extramural funding. He/she will work across departments, centers and schools to enhance medical informatics, public health informatics and bioinformatics at UAB.

Four years ago, the UAB School of Medicine committed significant resources to the establishment of a Division of Informatics in the Department of Pathology and the implementation of a campus-wide clinical informatics infrastructure. During that time the division grew to five faculty, hosting multiple informatics resources in sequence and image analysis, and offering a suite of well attended immersive courses in Biomedical Informatics and Computational Pathology for both medical and graduate trainees. The new Director will be expected to continue the expansion of the Division through additional recruitment and new investments that further advance its research, education and service portfolio. The Director will participate in the development of two new Institutes at UAB, Informatics and Personalized Medicine.

The UAB-School of Medicine is located in Birmingham, AL and is ranked 26th in NIH funding. The UAB Health System is a >\$2 billion/year enterprise, consisting of University Hospital (981 beds; with installed Cerner enterprise software), The Kirklin Clinic (1,100 physician group practice), VIVA Health (a regional HMO), UAB Highlands Hospital (specialty hospital), Prime Care (primary care network), and affiliated hospitals in Montgomery and Bessemer. UAB has established high performance computing and high speed connectivity to the Lambda Rail, as well as supports the Alabama Supercomputer Facility in Huntsville, AL. The UAB Comprehensive Cancer Center, together with its partner HudsonAlpha Genomics Research Institute in Huntsville, is a key participant in The Cancer Genome Atlas.

The position offers an excellent and comprehensive compensation and benefits package. All inquiries should be directed to: **Kevin A. Roth, M.D., Ph.D., Robert and Ruth Anderson Professor and Chair, Department of Pathology, UAB, 619 South 19th Street, WP 210, Birmingham, AL 35233-7331 email: path-informdir@mail.ad.uab.edu**. Interested applicants should submit: 1) a cover letter; 2) curriculum vitae with the names of three references; and 3) a statement of research interests.

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Director, NASA Astrobiology Institute

NASA seeks a new Director for the NASA Astrobiology Institute (NAI). The ideal candidate will be an internationally recognized scientist with proven experience in leading or managing large interdisciplinary research programs or projects, possessed with a vision for leading the Institute into the future.

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Interested individuals should apply directly to USAJobs at **www.usajobs.gov**

by May 1, 2015.

In the keyword search box, type vacancy number "AR15S0001". Select "Director, NASA Astrobiology Institute", then click "**Apply Online**".



The University of Texas at San Antonio

Robert A. Welch Endowed Chairs in Chemistry at The University of Texas at San Antonio

The Department of Chemistry at The University of Texas at San Antonio (UTSA) seeks internationally renowned scientists to fill two newly established Robert A. Welch Endowed Chairs in Chemistry. The research area of one Chair is expected to encompass the interface of chemistry and biology. The research area of the other Chair can encompass any area of modern chemistry. Each Welch Chair includes a generous endowment, a highly competitive salary, and ample modern research space. Significant additional financial resources and state-of-the-art facilities are available. The scientists occupying these Welch Chairs are expected to play leadership roles in ongoing departmental growth and faculty recruitment. Opportunities are available for collaborative initiatives at UTSA and with nationally renowned area institutions, including the University of Texas Health Science Center at San Antonio and the Southwest Research Institute.

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Nominations and inquiries can be sent to the Department Chair, Dr. Waldemar Gorski, at the following address: Department of Chemistry, UTSA, One UTSA Circle, San Antonio, TX 78249 or via email (**Waldemar.Gorski@utsa.edu**).

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July 1 for fall | December 15 for spring

bu.edu/bioinformatics/

**BOSTON
UNIVERSITY**

Biodomain Researcher



Purpose

Candidates are sought to fill a scientist position in Shell's Biofuels Research and Development program. The program is focused on delivering Next Generation Biofuels into the market, primarily from ligno-cellulosic feedstocks, by both biological and thermochemical routes.

Role Accountabilities

The role will be based in Shell's Projects & Technology Group, located in the Shell Technology Center, Houston, Texas. The successful candidate will work within Shell's in-house Microbial Biofuels team, scaling-up Shell's proprietary ligno-cellulosic biofuel process from the bench to production scale. The challenges in such a process range from soil carbon and ecosystem services analysis, through enzyme hydrolysis, solid and liquid phase fermentation, to molecular microbiological transformations.

Potential candidates will be engaged in a range of activities such as: ecosystem service modelling, molecular transformation, microbial pathway evolution, enzyme hydrolysis, novel fermentation, and organism research.

Responsibilities will include: design and implementation of experimental programs aimed at producing commercially viable biofuels from micro-organisms, taking into account a wide range of contributory factors; and identifying opportunities and engaging with the development of commercial plans.

Candidates are expected to have excellent intellectual and analytical ability, the enthusiasm to progress their insights, strong teamwork and leadership skills, as well as the ability to broaden outside of their area of expertise. The successful candidate will be expected to work with Shell engineers globally, as well as with external partners.

Required Qualifications/Skills

Ideally, the successful candidate will have a PhD (or be in their final year/ write-up of a PhD) in one of the following areas, or a related field:

- Microbiology
- Biochemistry
- Environmental Microbiology

They will have demonstrated a willingness to learn and apply cross-discipline approaches to solving problems, and be happy working in a tight-knit team.

Experience in one or more of the following areas would be a distinct advantage:

- Soil carbon pathways and sequestration
- Metabolic pathway improvement via transformation
- Enzyme hydrolysis
- Solid or liquid fermentation (batch or continuous flow at pilot scale)

Application Requirements

- To be eligible for Graduate full-time opportunities, you should be in your final year of study or have less than three years of work experience.
- You must have a minimum Cumulative GPA (CGPA) of 3.20.
- Candidates for regular U.S. positions must be a U.S. citizen or national, an alien admitted as permanent resident, refugee, asylee, temporary resident, or an individual who possesses valid work authorization. Individuals with temporary visas (H-1, H-2, J-1, F-1, etc.) or who require sponsorship for work authorization now or in the future are not eligible for hire.

How to Apply

- In order to be considered for this position you must apply online at www.shell.us/careers.
- In the "Students and Graduates" section, click on "Shell Recruitment Day" and then create an account. When entering your contact details, select "Other" in response to "Where you found out about this Shell opportunity," click "Next" and then type in "Biodomain Researcher."
- We require a completed application, an updated copy of your résumé and an unofficial copy of your transcripts / grade report prior to be considered for an interview.

EDITOR'S PICK



Genetic legacies of rank and file

From John Orchard

How can anyone know that the "Roman invasion left no genetic legacy" (21 March, p 10)? Many of the prominent invasions of the UK featured an elite warrior class from a particular place taking control. Often, most of the soldiers bearing arms were not from the same places or countries as the elite.

In the case of the invasion by the Roman emperor Claudius in 43 AD, some of the elite senior soldiers and administrators were undoubtedly from the small area around Rome. However, the vast majority of the soldiers would have come from all around the empire.

A great number of these will have been genetically linked to British people if they came from almost anywhere in Western Europe, especially from Gaul or the Low Countries. The Romans may well have left a legacy in the genetic make-up: it's just that it is the same signature as that of the people who were already here.

Bishop Norton, Lincolnshire, UK

The Editor writes:

■ Indeed, the majority of the Roman soldiers posted to Britain were not Italian, but recruited from Gaul and Germany; but the point remains that the Italian elite hardly left any genetic imprint.

To read more letters, visit newscientist.com/letters

I smell tomato, you don't smell at all

From Guy Cox

Asifa Majid's points to the paucity of the English language of smell (28 March, p 27). Could the issue lie in our noses? For example, I can recognise a musty smell, but my wife finds musty smells on items that have no such smell to me – clearly there is a chemical in the "musty" family I don't respond to. On the other hand, freesias are odourless to her, whereas their perfume is extremely strong to me. (I think I got the better deal.)

Imagine trying to develop a consistent vocabulary for colours if everyone was colour-blind in a slightly different way. That's where we seem to be with smell. Could the Jahai people that Majid works with, who find it easy to converse about smell, have less genetic diversity of smell?

Madsen, New South Wales, Australia

Knowledge, chance and circumstance

From Peter Standen

Regina Nuzzo describes someone with a frequentist approach to statistics tossing a coin for a drink in a pub (14 March, p 38). They would be a dull drinking companion, insisting that when a tossed coin lands unseen in the hand it isn't sensible to talk of the probability of it being a head. Until the outcome is known it is surely sensible to wonder whether I'll get a free drink.

The important event here is the gaining of human knowledge, not what state an unobserved coin is in. Our frequentist's real problem is the belief in a scientifically knowable objective reality that exists independent of observations. Similarly, from the human knowledge perspective there is really no need to tie oneself in knots to explain the

"existence" of the Higgs: it is highly probable from what we know at present. Your story on quantum Bayesianism (10 May 2014, p 32) makes a similar point. *Darlington, West Australia*

Shaming carbon emitters fairly

From Leslie Coull

Bob Holmes names China as a "bad apple" that causes "harm out of all proportion" because of its carbon dioxide emissions (21 March, p 46). This seems eminently unfair. China has a population equivalent to about 20 other countries put together.

To be fair, one should look at the carbon dioxide emissions per head. Among the top 20 offenders in 2011 statistics, China is 15th with 6.52 tonnes per head per annum. The worst is Saudi Arabia with 19.65, followed by the US with 17.62 – almost three times China's per-capita emissions. The UK value is 7.92. *Nyon, Switzerland*

Don't bank on arbitrary credit

From Douglas Bruce Kell

I have enormous respect for Andy Haldane of the Bank of England, but his interview hides the constraints under which he operates (28 March, p 28). The book he cites, *This Time is Different* by Carmen Reinhart and Kenneth Rogoff, presents the message that the main cause of financial crashes is letting banks (and their functional equivalents) lend money they do not have.

If the government stopped that and set a small transaction tax on financial trades, it would replenish the treasury and stop the casino activities that recently bankrupted the country and will likely do so again if left unchecked. *Manchester, UK*

Ancestors, gods and ghosts

From Gwydion Williams

You ask "Should we thank god for civilisation?" (28 March, p 5). But what counts as "god"? Cults that honour dead human ancestors are common among tribal peoples, and consistent with the elaborate burials we find from very early on. They may coexist with the idea of gods and goddesses, with some gods viewed as ancestors fathering or giving birth to human offspring and some human ancestors being promoted to be demigods or gods.

We can only speculate about what the people of Gobekli Tepe or the Maya city of Ceibal believed. But they may have simply believed in ancestral ghosts, with the notion of gods and goddesses emerging later to serve the interests of professional priests.

The notion of a single all-powerful god definitely comes much later. Some civilisations have managed fine without it, including most of East Asia. The Supreme Being of Hindu faith is a rather abstract and remote being. *Coventry, West Midlands, UK*

Atheism and theism are faiths

From Chris Ford

Agnosticism and atheism are not vague or interchangeable terms, as apparently claimed by Connaire Kensit (4 April, p 57) in response to my letter. The *Concise Oxford Dictionary* defines an agnostic as one "who believes that nothing is known or can be known of the existence or nature of God". This implies existence or non-existence are equally unprovable.

Atheism and theism are both faiths: nothing wrong with that. Religious friends of mine stress the importance of faith – belief in a blatantly visible god floating up in the sky would be no big deal!

“That article on belief was one of the most enlightening things I’ve ever read”

@charliparkinson on Twitter in response to “Beyond belief” (4 April 2015, p 28)

The business of science, however, is that which is subject to observational and experimental verification. All else is speculation.

Aldridge, West Midlands, UK

Have aliens been and gone?

From Bernard Morcheles

Ian Simmons suggests that “alien civilisations may be out there, but have never managed to visit us simply due to budget cuts” and Adrian Ellis that “It’s the quiet ones that are clever, not the shouters” (7 March, p 53). Perhaps a civilisation a billion years more advanced than ours did visit undetected, said “Yuk!” and left.

Summit, New Jersey, US

Wielding the power of a universe

From Hillary Shaw

Your article on radio bursts coming from space mentioned

the categorisation of other possible civilisations (4 April, p 8). A Kardashev Type III civilisation is defined as one that controls the power output of a galaxy. Could a Type IV civilisation control the power output of its entire universe? What would this look like to a Kardashev Type 0 civilisation like ours? Would we recognise such a civilisation, or just perceive its actions as “the laws of physics” – or worship it? *Newport, Shropshire, UK*

Who or what gets custody of the cat?

From Mabs Taylor

I was interested by your article on the possibilities of swapping body parts (28 February, p 10). This was explored by Gordon Rattray Taylor in his 1968 book *The Biological Time Bomb*, raising some of the practical and ethical consequences of such procedures. One problem of a head/body swap that he foresaw would be deciding who owned the assets. *Knutsford, Cheshire, UK*

Health, death and feeling the heat

From Eric Kvaalen

In your special report on the future of healthcare in the UK, you say: “If the low rates of cancer seen in the richer portion of UK society were replicated across the nation, 19,200 fewer people would die every year” (21 March, p 22). People who don’t die of cancer die of something else. What one can say is that 19,200 people would live longer lives.

Les Essarts-le-Roi, France

From Rapier Dawson

I was amused to see the “rising threat of heat” discussed right next to the “winter crisis” in your special on challenges facing the UK National Health Service. I presume the winter crisis is a surge of illness caused by cold weather. So which is worse, warm or cold?

Houston, Texas, US

The Editor writes:

■ Death and illness from extreme heat will rise with climate change.

Despite the continued possibility of extreme winters with climate change during the 21st century, death and illness from extreme cold will drop, but drop less.

Meanwhile, back on Planet Earth...

From Greta Sykes

If I am to believe *New Scientist*, we are about to enter a glorious age of leisure with robots doing all the work, electric cars driving us to beauty spots and other planets being available via space travel, if we get bored on Earth.

Such is the gist of many of your recent articles on technical wizardry – and it leaves me wondering whether you have already left this planet.

Where we humans live, we face catastrophic changes through military extravagances, monopolisation of land and property and environmental damage taking us to the brink, turning Earth from friend to enemy. Have a care and think of Mother Earth!

London, UK

TOM GAULD

THE UNDISCOVERED SPECIES



For the record

■ The correct reference for an article on panda sociability by Vanessa Hull et al is DOI: 10.1093/jmammal/gyu031 (4 April, p 17). Not “jmamma”: our therapist is concealing her glee.

■ We now know that, in our article on belief, the extensively quoted neuroscientist at George Mason University in Fairfax, Virginia, should have been called Frank Krueger (4 April, p 28).

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WHAT might be the hidden significance of the number 187.5? We reported that a measure of the delay between the arrival of low- and high-frequency components of mysterious bursts of radio waves comes in exact multiples of 187.5 (4 April, p 8). Chris Conklin immediately wrote to point out that 1.875 is “the smallest positive solution of $\cos(x)\cosh(x) = -1$ ” and appears in the formula for calculating the frequency of a crystal oscillator from its size and properties. But the link to quartz clocks seems circumstantial to us.

IDLY searching for the number 187.5 - key to the astronomical mystery described above - finds it surprisingly often. A quarter bottle of wine is 187.5 millilitres; we find chocolate sold in units of 187.5 grams; and, probably for a reason, one that escapes us, some antidepressants are delivered in tablets containing 187.5 milligrams of the drug. In a further example of our ability to see patterns

in noise, we sought to complete the set of drug, red wine and chocolate with cheese, in 187.5 g portions.

We thus discovered instead that this is a common, if absurdly precise, conversion of the US recipe measure “one-and-a-half cups”. If the radio bursts are a signal from aliens, are they looking for our lunch?

THINKING of aliens wielding odd numbers prompts us to delve into our piling system to draw out responses to the suggestion that the number 37 is encoded in our DNA, and has odd numerological properties (20/27 December 2014, p 61). Mick Crisford was “less than impressed” with these, because they depend on us happening to count in base 10 (7 January, p 54).

Chris Goldfrap points out that the hexadecimal number 5B has a similar range of properties and that aliens have loads more possible code numbers to choose from. Feedback expects a proper citation from the aliens.

PERHAPS those mystery radio signals come from distant galaxies? This leads us to ask: how can we tell these aren’t made of antimatter? This is one of those “big questions” that has long concerned us (3 August 1996, p 36).

Did astronomers answer this by observing whole clusters of galaxies colliding without producing the fireworks expected from matter meeting antimatter (30 August 2008, p 14)? Not according to a press release from the Santilli Foundation, which claims that a telescope made with concave lenses has confirmed the detection of antimatter galaxies.

Concave lenses don’t focus light, so how would a telescope that used them work? The Santilli press release helpfully explains: “The only possibility for a telescope with concave lenses to focus images is that the antimatter-light has an index of refraction opposite that of matter-light... a negative index of refraction can only occur if antimatter-light is repelled by matter, namely matter and antimatter repel each other.” *Klar?*

BUT wait. The above explanation for antimatter-detecting anti-lenses speaks of the index of refraction of light. It’s matter that has one of those. So, presumably, does antimatter.

And you can’t have “matter-light” and “antimatter-light” because light is made of photons, and photons are identical to antiphotons. So what we appear to have is a new type of quantum fruitlooper – sneakily avoiding the word “quantum”.

Rereading the press release we do note an inherent duality in the author, who signs herself as “executive vice-president” of the Institute of Basic Research in one place and as “excessive vice-president” in a second.

WITH the UK election taking place on 7 May, Feedback is concerned that the country’s Education Council may be sending subliminal messages. These are detectable, however, by those who have served in the armed forces.

The Council promotes study in the UK and has been advertising the UK

University Fair 2015, in which more than 90 universities will take part on 16 May. Posters for the event, and the organiser’s website, feature a picture of a cheery student with a Union Jack flag on a stick over her shoulder.

The flag is upside down. To those steeped in, for example, naval protocol, this is traditionally a sign of distress. What message is the Council giving about education?

INVERTING a flag may also be an insult to our own dear Queen. Feedback finds this interpretation unthinkable, if not, in fact, illegal.

FINALLY, Feedback wishes to make a correction. Discussing the proposition that “anyone who suspects the probability of a set of independent failures occurring together to be vanishingly small should urgently make plans to cope with them all happening at once”, we noted the



suggestion that it could be called “Rincewind’s Rule” after the hapless wizard in Terry Pratchett’s *Discworld* novels (11 April).

It was, we insist, alliteration and not sexism that trumped precedence of attribution here: in fact, it was Granny Weatherwax who first enunciated the principle in *Equal Rites*, a slightly earlier emanation of Pratchett’s fantastical universe. Honest, Granny.

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An Oklahoma State University Department of Agricultural Economics survey found 80.44% of people want foods containing DNA to be labelled. We were cutting down on those that don’t...

Who's on top?

I found this spectacle (see photo) on Wimbledon Common. Is it an example of sexual dimorphism or are the participants fruitlessly confused?

■ We may be confused, but the ladybirds spotted by your correspondent on Wimbledon Common are not, and in all probability this mating will be extremely fruitful. The species is *Harmonia axyridis*, known in the UK as the harlequin ladybird and in the US as the Asian lady beetle.

It is extremely variable in appearance and it has been said that no two specimens look alike, but there are three main variants. *Succinea* is red or yellow with black spots varying in size and number; *conspicua* is black with two red spots; and *spectabilis* is black with four red spots. Females are larger than males. The most certain way to identify the species is to look at the black and white pattern on the pronotum, the plate that covers the thorax behind the head. In harlequin ladybirds, the black mark appears to form a W at the top.

Harlequin ladybirds are native to Asia but have been deliberately introduced to other parts of the world because they eat aphids, which attack plants. The beetle was first discovered in the south-east of the UK in 2004 and has now spread to all parts of England, with a few occurrences in Scotland and Ireland. High concentrations of the species in London suggest that some may have arrived with



the flowers and vegetables brought to New Covent Garden Market, but ladybirds are capable flyers and it is just as likely that some have been blown across the English Channel.

Their presence is being monitored in the UK because they are generalist feeders on

"Harlequin ladybirds are from Asia but have been introduced elsewhere as a useful predator"

other insects, including native ladybirds. Indeed, harlequin ladybirds are being blamed for the decline in numbers of other ladybird species. Their voracious larvae will even eat one another, but the adults are also fond of ripe fruit, to the extent that wine can be tainted by ladybirds lurking among the grapes. Pest control companies now target harlequin

ladybirds because they shelter from the cold in huge colonies in buildings, and if they wake up hungry they may bite people.

H. axyridis is generally regarded with suspicion in the UK and is an example of a highly successful invasive species. Undemanding in habitat, it can be found at ground level and in the treetops. It is omnivorous as an adult and, apart from other insects, will also consume mildew, pollen, honeydew and fruit. Females can lay up to 1500 eggs in a season and in warm weather the life cycle is complete within a month. They can live for up to two years and are adept at finding shelter in the winter. Tough and versatile, they are the insect equivalent of the grey squirrel, another invasive species well established in the UK. *Christine Warman*
Saltburn-by-the-Sea, North Yorkshire, UK

This week's questions

BRAIN GAIN

The hippocampi in the brains of London taxi drivers enlarge as a result of having to memorise the city's extensive street map. Actors are always memorising new lines and opera singers often have to learn words and music. What effect does this have on their brains?

Graham Thomas
St Albans, Hertfordshire, UK

RADIO GAGA

A car radio needs an external aerial to stop the car itself interfering with the signal. Yet the fob on the car key also works by radio and is effective even if I hold it near the steel garage door with the car on the other side. So how does it work?

Adrian Somerfield
Dublin, Ireland

INSECT IMPOSTOR?

A brilliant toddler has told me that a butterfly can't be an insect because it has more than six legs when it's a caterpillar. He's wrong, but I'm not sure why. What should I tell him?

Lynn Tylczak
Albany, Oregon, US

BUBBLE TROUBLE

Why is it that bubbles released at some depth in water appear to take on the shape of mushrooms as they rise?

Patrick Casement
London, UK

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